Tampere University

Tuomas Ilvonen

USING BUSINESS INTELLIGENCE TO SUPPORT MULTI-PROJECT MANAGEMENT

Faculty of Engineering and Natural Sciences
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ABSTRACT

Tuomas Ilvonen: Using business intelligence to support multi-project management
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Business intelligence has gained significant popularity in the last few years, and not least because of the fact that businesses are managing vast amounts of data in their daily operations. The subject area of business intelligence has not gained the same ground in academy as it has in practice, and our knowledge is lacking especially in the relationship of business intelligence and its organisational context. Business intelligence can integrate data, automate its processing and present it better, thus having something to give for various business environments.

In this master's thesis, the potential of business intelligence is explored in the context of a multi-project environment. The study is a qualitative single-case study on one division of a large Finnish industrial machinery manufacturer. The division is facing issues in managing the complex multi-project environment consisting of various types of projects. The environment is in need of ways to integrate its scattered project management information to enable better coordination. Business intelligence has been chosen as the way to explore solving these issues. Thus, the goals of this study were to understand the state of the organisation, identify its needs and issues further, and explore how those needs could be fulfilled with business intelligence tools. The empirical data was collected via semi-structured interviews and a research diary recording meetings relevant to the subject.

The most prevalent issues regarding multi-project management in the organisation were lacking in tools for both project portfolio management and resource management, lacking in information availability across both organisational units and projects, having too many tools for project management and no integration between them, and the poor quality of project management data. These issues were used as the primary drivers for the actual results of this thesis.

The three types of reports defined in this thesis were portfolio and project reports, resource utilisation reports and resource demand reports. In addition, the suggestions for further future included better integration of data between various organisational IT systems, mainly to better address the organisational dependencies faced in multi-project management. Business intelligence would also have the potential to renew management of the organisation in various other ways, but a first step was taken with these results. Thus, deeper research is still needed to explore the potential of business intelligence in multi-project management, and other contexts.

Keywords: business intelligence, multi-project management, reporting, project-based organisation

TIIVISTELMÄ

Tuomas Ilvonen: Liiketoimintatiedon hallinnan työkalut moniprojektiympäristön tukena
Diplomityö, 111 sivua, 4 liitesivua
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Liiketoimintatiedon hallinta (business intelligence) on kasvattanut suosiotaan viime vuosina, eikä vähiten siksi, että yritykset joutuvat hallitsemaan valtavia määriä dataa päivittäisissä toimissaan. Aihealueen tutkimus ei ole saavuttanut samaa suosiota kuin käytännön sovellukset, ja tietämys on heikkoa erityisesti liiketoimintatiedon hallinnan työkalujen sekä niiden ympäristön välisen suhteen osalta. Kyseisten työkalujen avulla voidaan muun muassa yhdistää tietoa eri lähteistä, automatisoida sen käsittelyä ja esittää tieto uusilla tavoin. Monipuolisten ominaisuuksiensa vuoksi näitä työkaluja voidaan hyödyntää monenlaisissa liiketoimintaympäristöissä.

Tässä diplomityössä tutkitaan liiketoimintatiedon hallinnan työkaluja moniprojektiympäristössä. Tutkimus on laadullinen tapaustutkimus, jonka kohteena on suuren suomalaisen teollisuuslaitevalmistajan yksi divisioona. Organisaation haasteet liittyvät erityyppisistä projekteista koostuvan moniprojektiympäristön hallitsemiseen. Uusia keinoja projektitiedon yhdistämiseksi tarvitaan, jotta kokonaisuutta voitaisiin koordinoida paremmin. Liiketoimintatiedon hallinnan keinot on valittu työkaluiksi näiden ongelmien ratkaisemiseksi. Työn tavoitteena oli kartoittaa organisaation tilanne, ymmärtää sen tarpeet ja ongelmat tarkemmin sekä tutkia, miten liiketoiminta tiedon hallinnan työkaluja voitaisiin käyttää tarpeiden täyttämiseksi. Empiirinen aineisto kerättiin puolistrukturoiduilla haastatteluilla sekä tutkimuspäiväkirjalla, jonka avulla kerättiin tietoa aiheeseen liittyvistä tapaamisista organisaatiossa.

Organisaation oleellisimmat moniprojektihallintaan liittyvät ongelmat olivat puutteelliset portfolio- ja resurssihallinnan työkalut, tiedon heikko saatavuus organisaatioyksiköiden ja projektien välillä, liian suuri määrä projektinhallintaan käytettyjä työkaluja ja integraation puute niiden välillä sekä projektinhallinnallisen tiedon heikko laatu. Näistä ongelmista saatuja tietoja käytettiin ratkaisujen kehittämiseksi.

Työssä määritettiin organisaatiolle kolme raporttityyppiä: projekti- ja portfolioraportit, resurssikäyttöraportit sekä resurssitarveraportit. Näiden lisäksi tulevaa raporttikehitystä varten ehdotetaan muun muassa parempaa tiedon integraatiota eri tietojärjestelmien välillä, jotta moniprojektihallinnan organisatorisia riippuvuuksia voitaisiin hallita paremmin. Liiketoimintatiedonhallinnalliset keinot voisivat uudistaa organisaatiota tässä työssä esitettyjen keinojen lisäksi monilla muilla tavoin, mutta tämä työ oli tärkeä ensiaskel kyseisten työkalujen hyödyntämiseksi tämänkaltaisessa ympäristössä. Syvempää tutkimusta liiketoimintatiedon hallinnan potentiaalista moniprojektihallinnassa ja muissa konteksteissa tarvitaan edelleen.

Avainsanat: business intelligence, liiketoimintatiedon hallinta, moniprojektihallinta, raportointi, projektiorganisaatio

PREFACE

I can barely remember the time I did not have a thesis project in my life. I cannot say I have particularly enjoyed working on it, but undoubtedly it has taught me a chunk. I have learned a lot about project management and organisations, but most of all, about myself.

I sincerely thank everyone who supported me during this project. I'd like to thank all the people I cooperated with in the case organisation. I took my time, but there was never a situation where I could not ask for your support, if I needed it. Well, I rarely asked for it, but I always had the option. I'd also like to thank my examiner Miia Martinsuo, who gave me thorough and useful feedback about my work, and made me feel encouraged.

Still, the biggest thanks go to my friends, my mom, and my dad. You have supported me my whole lifetime.

Special thanks to my running shoes, the local gym, and good music.

In Tampere, 28.1.2019

Tuomas Ilvonen

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LIST OF ABBREVIATIONS

BI	Business intelligence
CRM	Customer relationship management
ERP	Enterprise resource planning
PBO	Project-based organisation
PMIS	Project management information system
PMO	Project management office
PPM	Project portfolio management
R&D	Research and development

1. INTRODUCTION

1.1 Background

Modern organisations often gather vast amounts of data on their operations. This data is used to help the organisations make better decisions (Vliegen et al. 2006). However, especially when the amount and complexity of the data grows, and various data sources are needed, many obstacles to using this data efficiently can arise.

Business intelligence (BI) can be considered as the stack of the strategies, processes, applications, data, products, technologies and technical architectures used to support the collection, analysis, presentation and dissemination of business information (Dedić & Stanier 2017). It allows organisations to gain insights from data collected through a variety of data sources (Chen et al. 2012). The perks it can provide include automated data processing, monitoring and forecasting variables, and visualising information, amongst others (Chaudhuri et al. 2011; Ranjan 2008).

Reporting aims to bring information available to decision-makers, and with that information, rationalise decision-making processes. Different methods of reporting project information, such as visualising data, could help us make decisions in smaller timeframes, through being able to analyse information more efficiently (Killen 2013). However, visualising information is not the only way to contribute to this decision-making or data analysis efficiency. And it is not only the actual situation that can make the decision-making more efficient, but there are also activities that take place before that situation (Ghasemzadeh & Archer 2000). BI has the ability to contribute to both the actual situation and the preceding activities. For example, the mentioned automation of data processing can contribute to the activities preceding decision-making, while visualising information can contribute to the actual decision-making situation.

The use of BI in organisational contexts, and specifically in project management, seems to be an underresearched topic. At the same time, companies have trouble optimising their project portfolios and making the related decision-making processes rational (Martinsuo 2013). While BI is, from a general point of view, a popular subject of research, projects and project-related business have some qualities that make them different from other ways to arrange operations. For example, due to the uniqueness of projects, scheduling and resource needs can vary from project to project, and strict rules to manage the related data might be more difficult to establish. Finding the information needs in a multi-project environment, and finding ways to fulfil them using BI, are at the centre of this thesis.

This thesis studies the procedures of multi-project management in a case organisation that bases its operations on projects. The main goal is to define a BI based set of reports, a report frame, which would support the decision-making and multi-project management in the project organisation and could be implemented with the resources available to the organisation. Thus, the aim is to initially define a common communication and reporting platform for project business, as described by Müller et al. (2008), using BI. This type of integration of information was suggested to improve the efficiency of portfolio management. However, this study attempts to broaden the view and see how it could serve a project-based organisation as a whole.

1.2 Case organisation

The case company is a large Finnish industrial machinery manufacturer, and this thesis focuses on only one of its business areas. The case company is a publicly traded company, which creates special needs for reporting in its business areas and their product lines. The end products of the particular business area range from small, individual pieces of machinery or equipment to large solution-oriented projects costing tens of millions of euros. Due to the significant heterogeneity in the offering, this thesis will examine only the project division of the business area, which will be subsequently referred to as the case organisation.

A simplified organisational chart of the case organisation is presented in Figure 1.

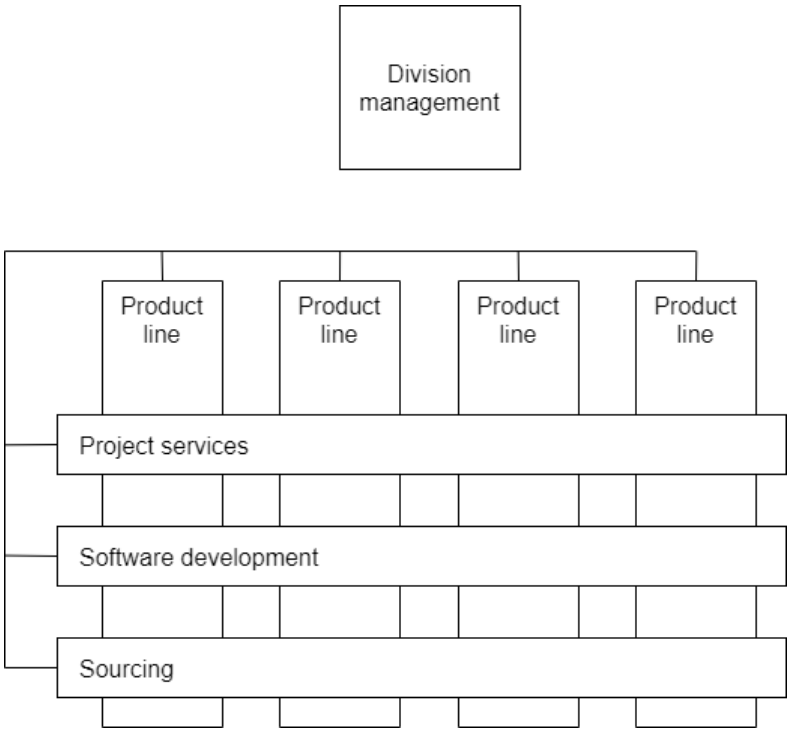

Figure 1. Organisational chart of the case organisation

In the structure of the case organisation, mostly the product line organisations and the cross-cutting functional entity of project services own the projects. The project services gathers various types of project expertise under it, for example project engineering, project management professionals and safety management. From the structure of the organisation, the developmental focus of the organisation is also apparent: software development is considered as the main development activity, while other project services (e.g. hardware engineering, configuration, sourcing) are more business-as-usual types of activities. While the developmental focus is on software, research and development (R&D) activities are pursued within the product lines, too. The industry is moving towards a more automated future, and this is even emphasised in the strategy of the both the case organisation and the whole company. As the solution-based approach for customer projects is becoming increasingly prevalent, projects need to use expertise outside of the product lines they are executed by. The largest projects executed by the organisation, which combine the expertise of many product lines, are good examples of this solution-based approach.

The focus of the organisation is on customer delivery projects. However, the developmental aspect is highly relevant in this context, since a major portion of the development projects are executed as parts of these delivery projects. This is a significant detail for this study, as it leads, for example, to a high level of interdependencies between projects, and a need for additional communication between projects and organisational units. These implications will be further described and discussed along the thesis.

As the case organisation's projects are growing in number, getting more complex and dependent on stakeholders, new tools to manage the whole are needed. Before, it was possible to manage the stack of projects with less structured methods and tools, but now, the need has been recognised. The case organisation adopting a new project management information system (PMIS) quite recently has also sparked a desire to support the use of this system and leverage the data gathered through the system. Combining these two aspects, the need for more structured tools and the desire to support and utilise the new information system, the organisation came up with a potential solution: business intelligence. While the high-level benefits of this type of a solution have been recognised in the organisation already, a deeper investigation is still required.

Using BI, the case organisation wishes to improve its project business in terms of:

- forecastability,
- information availability, and
- decision-making transparency.

Thus, the deeper investigation, which is done through this thesis, aims to develop an understanding of if these goals can be achieved, and how. The main goal, however, is to

improve the multi-project management capabilities of the case organisation, primarily through attempting to solve the critical issues the organisation has.

1.3 Research objectives and scope

Currently, the case organisation is lacking in tools to manage its projects in a unified manner. Project data is scattered across multiple information systems and a clear picture of the whole project landscape is hard to form. The current information systems provide information with bad accessibility, and the information available is inadequate and not seen entirely fitting for the current ways of working.

To support solving these issues, the needs of the organisation in this regard should first be identified. For this, creating a thorough understanding of the context is required. When the context has been understood, and the needs have been identified, the study aims to explore how those needs could be fulfilled with BI. The above sequence of actions in mind, the research objectives of this thesis are:

1. To understand and identify current multi-project management practices and issues in the case organisation
2. To identify the needs faced in terms of project reporting
3. To explore how found needs could be fulfilled with the business intelligence tools available to the organisation

With fulfilling these research objectives, it will be also discovered how BI could be utilised in the multi-project environment in general. The context, as described in the previous subchapter, is complex and likely to have plenty of different, potentially conflicting, needs. Thus, the proposed needs, and consequently the BI solutions, would have to be prioritised. The research questions of this thesis are formulated as follows:

RQ1: How could business intelligence be used to support multi-project management in the case organisation?

RQ2: What should be prioritised regarding business intelligence development in the case organisation?

As a concrete way to support the project business needs or the case organisation, the goal of this thesis is to create a BI based project report frame for the needs of the organisation. The report frame will consist of the following elements:

- Main reports, their descriptions and rationale
- Ideas for future reports

The main reports are ones that should be prioritised, and the organisation should be able to implement them quickly. On the contrary, the future reports might not be immediately ready for implementation, and thus, they will be defined more loosely.

To address the forthcoming implementation stages of the reports, suggestions for those stages will be presented as results, with the focus still being on the actual reports. With the results of this thesis, the case organisation wants to be able to build a set of project reports that would fit its project business needs, help overcome its project business related problems, and support the use of critical enterprise information systems, especially the newly adopted PMIS.

From the methodological standpoint, this thesis will apply a case study methodology, exploring a single case. Semi-structured interviews will be used as the primary data collection method, and this data will be complemented with a research diary consisting of the notes from the relevant meetings and discussions attended by the researcher. Company documentation such as process descriptions, guidelines, reports, report templates and meeting memos will be used as secondary data sources. Additionally, a literature review will be conducted focusing mainly on the subject areas of multi-project management, project portfolio management (PPM), project-based organisations (PBOs), business data representation, and business intelligence.

Regarding the scope, this thesis will thoroughly only address the multi-project management level. The management of individual projects will be studied for the parts it is relevant, which it might be, as those processes can influence the multi-project environment (Martinsuo & Lehtonen 2007). As another limitation to the scope, this thesis will focus on communication between internal actors. While external data could also used in BI, this is not currently in the interests, or within the resources, of the case organisation. As a third scope limitation, the underlying IT infrastructure of the organisation will not be addressed in this thesis, and no particular tools or systems will be explored. A fourth scope limitation stems from the broadness of BI as a technology stack. In this thesis, the exploration of BI tools will be limited to two distinct architectural parts: data sources and front-end applications. In reality, between these parts, a stream of complex processes occurs. These processes typically include data movement and streaming, data warehousing and different mid-tier functionalities (Chaudhuri et al. 2011). These different processes can be largely tool-dependent, and extensively technical, which is why they are not addressed in the scope of this study.

1.4 Structure of the report

The structure of the report is presented in Figure 2. The paragraphs below it will describe the content of the chapters in detail.

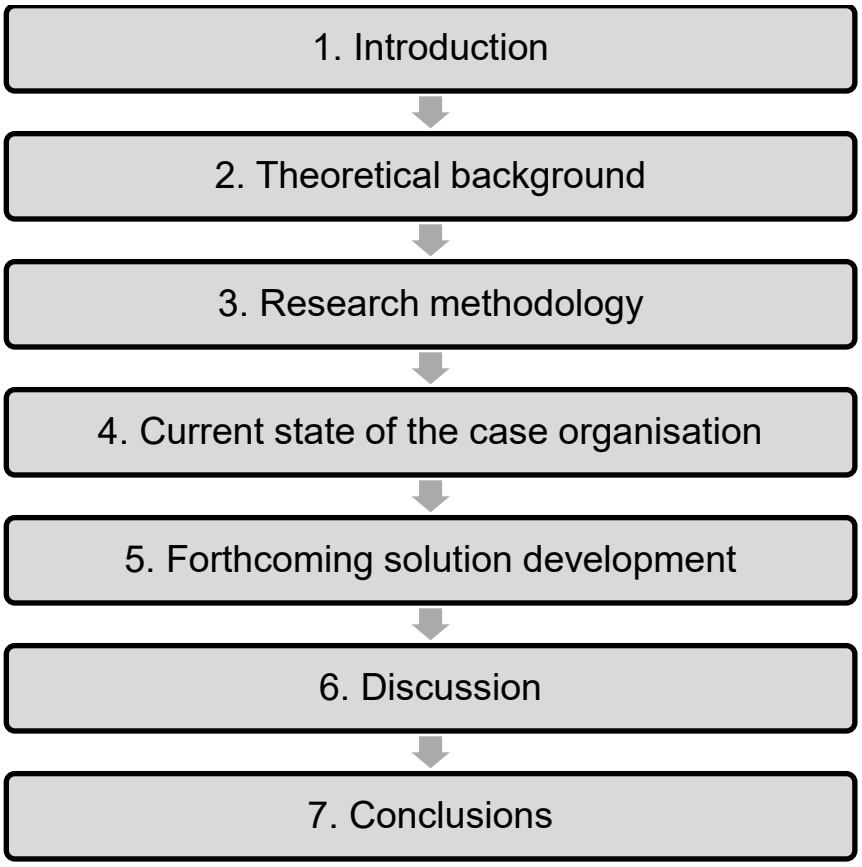

Figure 2. Structure of the report

In chapter 2, the theoretical background of the subject will be presented. The first part of this chapter will present and define the key concepts relevant to the subject area. This part will contribute to the basic understanding of the subject and set important definitions on which the subsequent discussion bases on. After that, the key areas of literature will be discussed in an in-depth manner. These include the characteristics of multi-project environments, prevalent issues in multi-project environments, and information flow improvement needs in multi-project environments. These areas analyse and clarify the landscape, which this research explores and is set in. Lastly, a synthesis of the literature subjects is construed, presenting two points of view: information needs in multi-project environments and potential of BI in these environments. The synthesis gives an overview of the subject and combines the different, individual subjects discussed in the earlier parts of the chapter. With the synthesis, a bridge between BI and project management is built, which is something prior research has not addressed.

In chapter 3, the research methodology of the thesis will be presented. The chapter provides insight into the methodological choices, and data collection methods and analysis used in this thesis. The chapter describes why the case study strategy was chosen, how the semi-structured interviews were used for data collection and how the qualitative data was analysed. These methodological choices also partly set the structure for the following chapters, the empirical parts.

In chapter 4, the current project management practices in the case organisation will be described and analysed. Here, the analysis will build on single-project management practices and move on to the multi-project environment of the organisation. The situation of PMISs, resource management practices and communicational practices will also be discussed. The chapter forms an understanding how the case organisation operates and of the reporting related needs present in the organisation. The understanding of the operations in the case organisation provides the context in which results of this thesis will be set, and the understanding of the reporting needs help find the prevalent issues to tackle and allow prioritisation in the thesis results. As the study is focusing on one organisation, the analysis is detailed and provides novel insights from the particular multi-project environment.

In chapter 5, the main results of this thesis, reports and guidelines to their development, will be presented. The results are built on the management practices and issues the case organisation is facing. Firstly, the organisational views regarding the report development are presented, giving contextual information about the concerns that should be addressed when formulating the actual results. Then, the limitations that should be taken into consideration in the solutions to be presented. After that, the organisational issues are placed into the BI context; again, building a bridge between multi-project management and BI, this time using the empirical data. Lastly, the chapter introduces the most essential report types for this multi-project environment and provides additional insight into some future reports and priorities regarding the implementation of these BI solutions.

Chapter 6 will discuss the findings from three viewpoints. Firstly, an important relation to previous research will be presented by comparing the organisational issues in the case organisation to the ones presented in prior literature. Secondly, the potential and limitations of BI in multi-project environments will be discussed. This section provides prominent insights for further research and gives ideas for those considering the potential of BI in new types of environments. Lastly, development recommendations and general considerations about the future of these matters in the case organisation will be presented.

Lastly, chapter 7 will conclude the thesis. It will present how the research objectives were achieved and provide answers to the research questions posed at the start of the study, and describe the contribution of the thesis in terms of prior research and knowledge. Managerial implications will be presented in a straight-forward manner. As last sections, the limitations of the research will be discussed and the recommendations for further research given.

2. THEORETICAL BACKGROUND

2.1 Key concepts

The relationships between the key concepts is presented in Figure 3.

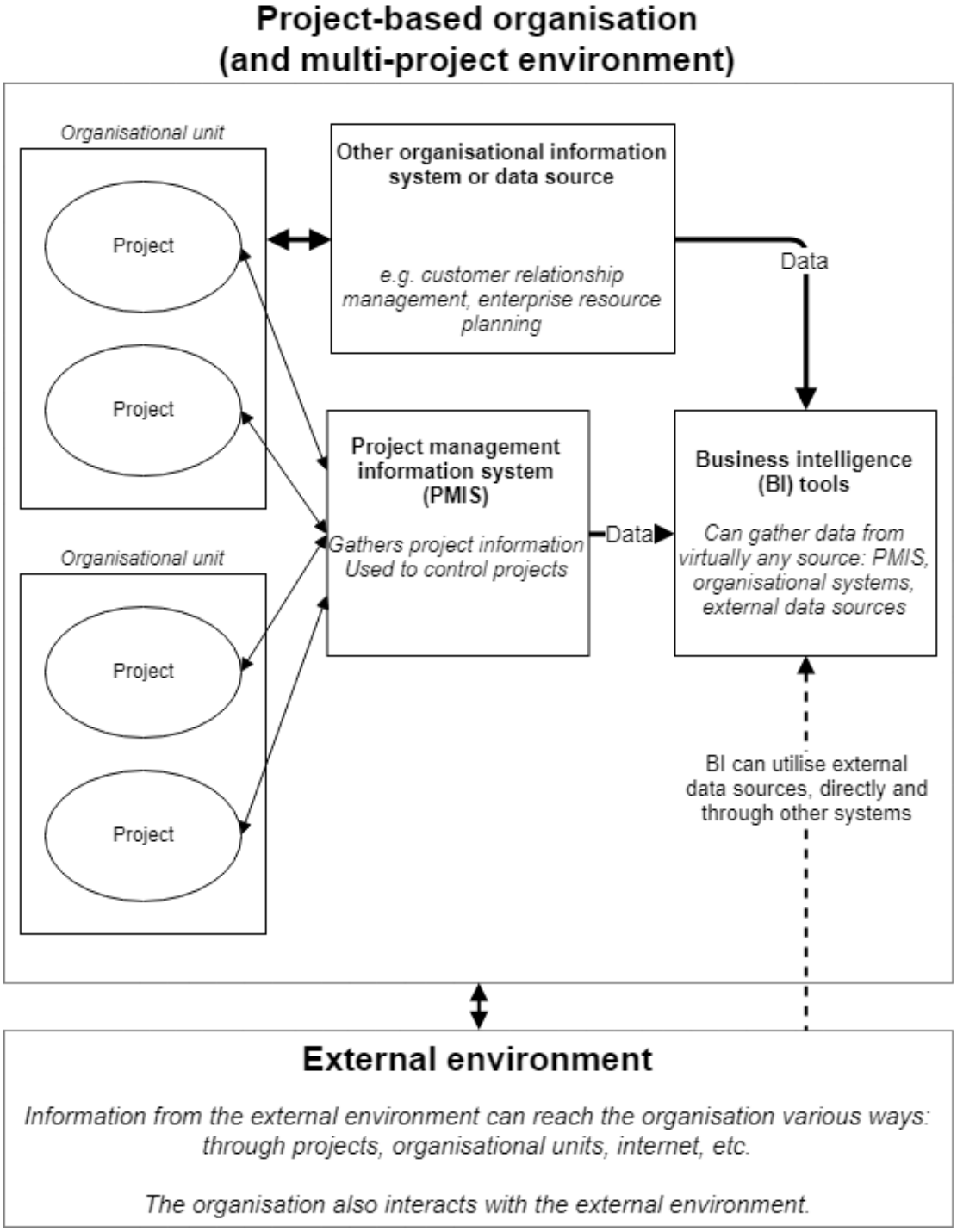

Figure 3. Presentation of the relationships between the key concepts

The figure presented above is constructed the way the case organisation conducts its operations. Thus, it is only one depiction of how those concepts could relate, and even within this context, the presentation could be done in various other ways. The main idea behind the figure is that BI could be used to connect and utilise all organisational and external data sources through one tool. As the project-based organisation, organisational units, projects, and external actors interact with each other, there can be various sources of data relevant to multi-project management. As the figure shows, using a PMIS brings all the project information together, but BI can have the ability to further connect that information to any other data, potentially creating a better connection between projects and the environment around them.

2.1.1 Project management

The Project Management Institute (2000, p. 4) defines project as *a temporary endeavor undertaken to create a unique product or service*, the key characteristics here being temporariness and uniqueness. According to another textbook definition by Artto et al. (2011, p. 17) a project is *a unique entity formed of complex and interrelated activities, having a predefined goal that must be completed by a specific time, within budget, and according to specification*. The latter definition is more specific, but both of these are widely accepted.

Let us consider the uniqueness of projects briefly. First, it means that each project may need different resources, such as people with different expertise. Also, since nothing exactly the same has never been done before, projects can be hard to forecast and predict, for example in terms of schedule and budget. Moreover, even though a project has a predefined goal, the goal or the ways to achieve that goal, i.e. specifications, may change along the way. This is a common occurrence especially in software business, where many software development methodologies prepare for this, for example, by making the development an iterative process with constant customer feedback.

Projects having a predefined goal, as mentioned by Artto et al. (2011), can be seen as a form of temporariness. When the goal is considered reached, the project comes to an end. As the same goal can be reached in numerous different ways, a specification can be seen as one particular way to reach it. The definition by Artto et al. (2011) also emphasises a project not being only one task, but consisting of different related activities. In the definition by the Project Management Institute, this is addressed with the project results being a product or a service, which require a certain level of complexity. Mentioning product and service make it seem like a definition only usable for business projects. Still, both product and service can be defined quite freely, so the definition should be applicable to other project-like endeavours, too.

Project management is defined as the application of knowledge, skills, tools, and techniques to project activities to meet the aforementioned project requirements (Project

Management Institute 2000, p. 6). How these management practices are applied along the project duration, may then vary according to the different phases of the project (Artto et al. 2011, p. 25). While the actual execution phase of projects is the main focus of project management research, there are important activities to pursue before and after that. These activities and two different perspectives to a project are presented in Figure 4.

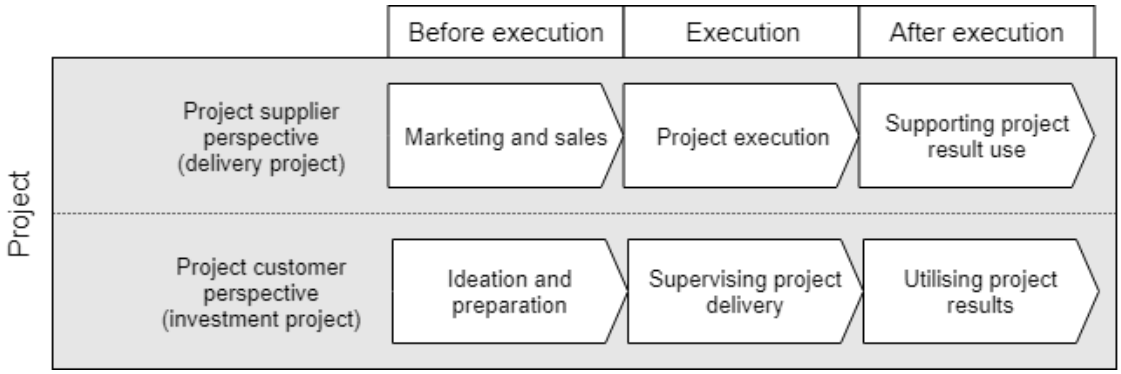

Figure 4. Two perspectives to a project (modified from Artto et al. 2011, pp. 42-43)

As the figure shows, one way to look at projects is the project supplier perspective, in which you are an actor responsible of the execution of the project. The complementing perspective is the customer perspective, in which you are an actor ordering the project from a supplier. As depicted, both of these perspectives are looking at the same project, from differing viewpoints.

However, in reality, the division of actors to supplier and customer sides might not be that clear. Say, an organisation wishes to develop a new product through a development project, which are often done in-house. In this situation, the organisation will be doing the project work, so that makes it the supplier. But also, the organisation will be the one utilising the results of the project and making an investment, which make it the customer. As projects can involve more than these two actors (Artto & Kujala 2008), individual supplier and customer, the actor types can be even harder to determine precisely in practice.

2.1.2 Multi-project management and project portfolio management

The most obvious definition of a multi-project environment is that it is one with several projects are being performed simultaneously, in parallel (Zika-Viktorsson et al. 2006). A closely related term is project portfolio management (Elonen & Artto 2003). In turn, project portfolio is often defined as a group of projects which are carried out under the sponsorship and/or management of a certain organisation, and which compete for the same scarce resources available. In a project portfolio, not all projects can usually be carried out because of the limitations in resource availability. (Archer & Ghasemzadeh 1999)

Project portfolio management (PPM) should, however, simply be seen as one variation of multi-project management (Midler 2013), in a similar way as Elonen & Artto (2003) use PPM and programme management literature to contribute on their multi-project management research. In the literature, the subject of PPM clearly focuses on investment projects, management of technology and innovation, R&D management, and new product development (Elonen & Artto 2003; Tikkanen et al. 2007). While these examine more internally-focused projects, Tikkanen et al. (2007) recognise a group of delivery projects as a portfolio, too. The research on managing these delivery project portfolios is scarce. In a project-based firm, external delivery projects are used for the firm's business purposes. (Tikkanen et al. 2007)

The reason why this terminology is discussed here stems from the characteristics of the case organisation. In the organisation, the line between delivery and development projects is somewhat unclear, with the two types of projects being commonly interconnected. The case organisation uses the term PPM in its multi-project management, but in this context, the meaning of the term might not be exactly the same as in the literature.

In this study, the term multi-project management will be used when referring to the management of multiple projects in general – not a certain group of projects. Respectively, the term PPM will be used when some type of a grouping of the projects is relevant.

2.1.3 Project-based organisation

Project-based organisations (PBOs) refer to a variety of organisational forms that involving creation of temporary systems for managing projects (Thiry & Deguire 2007). In a PBO, project is the primary unit of production organisation, innovation, and competition (Hobday 2000). To refer to this type of organisation or a firm, the term project-based firm is also used in the literature (e.g. Tikkanen et al. 2006; Turkulainen et al. 2013). Other variations of the term, meaning essentially the same thing, include projectified, project business, project-led, multi-project and project-oriented companies or organisations (Huemann 2010).

PBOs are considered to be strong in fulfilling organisations' innovative needs, responding to uncertainty, coping with emerging properties, responding to changing client needs and learning in real time (Hobday 2000). As industrial needs have changed from essentially stable customer requirements and slowly changing technology to tailored designs and rapid evolving of technology, new organisational forms such as the PBO have gotten more popular. Naturally, these reforms in organisations require different types of governance and control. (Turner 1999)

In a pure PBO, no functional departments would exist. Still, PBOs come in a variety of organisational formats, and can choose to support their organisation of projects with more permanent structures. The pure PBO can be seen as weak in coordinating activities and

learning between projects, which is why the supporting structures could be seen as beneficial to organisations. (Hobday 2000) However, most PBOs seem to combine these project structures with functional ones to different extents.

These types of multi-project environments are complex, and so is their coordination. They require fast decisions both on single-project and multi-project levels, for example regarding resource allocation and managing interdependencies between projects. Complex projects benefit from dedicated project management tools, and in a multi-project environment, managers have the need to follow things such as project status and resource allocation decisions made by project managers. One way, and a common one, to manage this complexity both on single-project and multi-project levels is a centralised PMIS. (Caniëls & Bakens 2012)

2.1.4 Project management information systems

Project management information systems (PMIS) are intended to support project managers in decision making. PMISs should help project managers plan, organise and control projects. (Caniëls & Bakens 2012; Raymond & Bergeron 2008) PMISs do this by gathering, integrating and disseminating the output of project management processes among project participants (Lee & Yu 2011). However, not all projects benefit from the use of PMISs in the same way. A major contributor to the utilisation of a PMIS seems to be project complexity, meaning the most satisfied users (project managers) tend to be those who handle larger and more complex projects (Ali et al. 2012; Ali & Money 2005).

In her study, White (2001) found project management software being the most widely used project management tool or method, right up there with Gantt charts. While it has been over 16 years since this study was conducted, there is no reason to suspect that these types of IT tools would be less relevant in modern project management. Instead, it seems that almost all organisations rely on information systems in project management, but in the context of multi-project, programme and portfolio management, these systems could be exploited significantly more (Ahlemann 2009).

As implied, PMISs no longer focus on only simple project management, such as scheduling and resource management, but they have become more comprehensive, and can now support the entire life cycle of projects, programs and portfolios. Due to the increased complexity, the design, implementation and operation of these systems has become a new challenge for PBOs. (Ahlemann 2009) Despite these challenges, using a PMIS has become a necessity for many firms, as it clearly helps in achieving project success (Raymond & Bergeron 2008).

The quality of the PMIS information is considered to be one of the most important factors in the success of a PMIS (Ali et al. 2012; Ali & Money 2005; Caniëls & Bakens 2012; Raymond & Bergeron 2008). A PMIS with high quality information is more likely to be

used (Ali & Money 2005), and this may indicate that the more satisfied users are with the system, the more they will use it (Caniëls & Bakens 2012). As PMISs gather data from users, and distribute it again to users in different forms, and as the system is used more, the more comprehensive the data will get. Again, as the data quality gets better, we could expect the system be used even more, and it seems like a positive feedback loop.

Organisations tend to use many different information systems for different purposes. One example are enterprise resource planning (ERP) systems, which were developed for manufacturing but might not support other processes, such as project management (Markus & Tanis 2000). Efficient project management might need the financial or other type of information stored in another system. And even if no such integration was needed, organisation can struggle to produce relevant reports from their data through the native interfaces of PMISs.

As the use of PMISs could benefit from better utilisation of the data stored in them, and organisations might struggle to integrate data between different information systems, there seems to be a call for more comprehensive systems to enable better information access. One solution to these issues is BI, which can have the capability to combine data across systems and produce automatic reports with a high degree of customisability.

2.1.5 Business intelligence tools

Business intelligence tools allow organisations to gain critical insights from the structured data collected through various enterprise systems and other data sources (Chen et al. 2012). Thus, BI systems can leverage the large data infrastructure investments (e.g. ERP systems and PMISs) made by organisations, and are a way to utilise the value in the organisational data resources (Elbashir et al. 2008). While these purposes allows a common spreadsheet tool to be considered a BI tool, the focus on this thesis will be on modern tools that have dashboard and visualisation features, and are suitable for automated handling of large amounts of data. Examples of these types of tools include software such as Microsoft PowerBI and QlikSense.

BI can be defined in numerous different ways (Dedić & Stanier 2017), and benefits expected from them differ from organisation to organisation (Hannula & Pirttimäki 2003). Processes that fall under the term of BI can manage the whole lifecycle of data in an organisation, all the way from retrieving data from databases, to moving, storing and manipulating the data, and lastly, to the presentation of the data (Chaudhuri et al. 2011). Thus, for the purposes of this research, there is no point in trying to find an exact definition for BI, as it would still be a vast umbrella term that can capture almost any data processing step imaginable in an organisation. This being said, it seems more beneficial to discuss the main benefits of these technologies.

Organisations expect BI to provide them better information, better observations regarding the surrounding business environment, more knowledge, improved information sharing and easier data analysis, amongst others things (Hannula & Pirttimäki 2003). While BI, as a term, is nothing new, these expectations might have changed drastically in the last 15 years, especially since the technological solutions that make up BI have certainly evolved. Thus, is no doubt the landscape has changed, but it is safe to say that the expectations have not lowered, and BI can still serve a variety of purposes in organisations. Still, the main purpose of BI remains – it assists organisations in decision-making.

2.2 Decision-making and business intelligence

2.2.1 Decision-making limitations

Decision-making is affected by "bounded rationality", in which the quality of the decisions suffers from

- Flaws (incompleteness and inaccuracy) in information,
- Human cognitive limitations, and
- Finite amount of time. (Killen 2017)

Firstly, the flaws in information can pose questions such as "is the information accurate" and "is all the relevant information available to the decision-maker". In terms of this research, the availability of the information is the more relevant aspect, as it could be directly affected with the systems used. Information accuracy, on the other hand, is more of a question whether the users of the systems provide the right data for the systems. To help overcoming this limitation of information availability, the information should be made as complete as possible. As data is often scattered across different enterprise systems (Markus & Tanis 2000), any of the systems by themselves might not provide the complete information. Thus, to provide complete information to be available easily, one solution would be to integrate it into one system. Integrating the information can also help overcoming then human cognitive limitations, as this could free up the decision-makers mind from combining the information, if it is already combined through the system. On the other hand, the decision-maker could use other tools to combine that information, and saving their cognition, but this in turn would consume the time resources a decision-maker has.

The human cognitive limitations and time restrictions also are tightly related to the cognitive fit theory presented by Vessey (1991). According to her, decision-making performance has two dimensions: accuracy (i.e. quality) and time. Basing on this theory, the performance on a decision-making task is enhanced when there is a cognitive fit between the task and the presentation of the information. For example, if a decision-maker would

need to know the values of individual data points, and the data points are known beforehand, a tabular representation of the data could be optimal. On the contrary, if the decision-maker would need to find out if there is a correlation between two variables, a simple graph with the two variables as axes would probably be a better fit. The latter example can be related to the old saying: "A picture is worth a thousand words", meaning, in this context, that it might be easier to extract more complex information through visual cues, rather than looking at numerous data points separately. Later on, the cognitive fit theory has been widely used as the basis of research (e.g. Basole et al. 2016; Huang et al. 2006; Killen 2017; Speier 2006; Umanath & Vessey 1994).

These explorations of decision-making limitations support the importance of information availability to the decision-maker. Firstly, information should be complete (and accurate), meaning all the relevant information should be available to the decision-maker. Secondly, information should be available to the decision-maker in such a way that personal cognitive limitations do not hamper the performance on decisions, i.e. presented and combined in a manner that these tasks do not need to be completed in cognition. Thirdly, leaving less of these tasks to the decision-makers saves their time, meaning the information should be as readily available as possible when encountering a decision-making task. As Ghasemzadeh & Archer (2000) describe, some tasks related to decision-making can be completed "offline" – before the actual decision-making situation, and this should be pursued to save time. In many ways, BI tools have the potential to improve information availability and help decision-makers, and organisations, overcome the presented limitations.

2.2.2 Business intelligence improving information availability

There are various different benefits sought from BI solutions, such as better information quality, better observations of the external environment of organisations, and growing the knowledge-base (Hannula & Pirttimäki 2003). However, here, we focus on the aspects that have the potential to improve overall information availability in an organisation, and specifically from an internal perspective. As discussed in the previous section, many of the limitations in decision-making are connected to information availability.

Firstly, as integrated management "super systems" are just a fantasy, at least for most organisations (Markus & Tanis 2000), being able to utilise data scattered across various enterprise systems can be crucial. Today's organisations tend to use specialised tools for different processes, while those processes are still related to each other. BI tools can allow the interplay between those processes by integrating the data across systems and presenting it through one system. This can save time from both data suppliers and BI users. An alternative solution could be moving the data between different enterprise systems, but using BI for this can reduce IT infrastructure costs by eliminating redundant data extraction processes and duplicate data in different systems. (Wixom et al. 2011) As modern BI tools seem to be built with the goal of users being able to access the information easily,

with the data being in one place, they can also be used as platforms to share all relevant information through one point of access. Being able to use these platforms through a low-level interface, such as a web browser, could be considered a manifestation of this emphasis on easy access. For example, tools like Microsoft Power BI and Qlik Sense offer browser interfaces as their primary means of report and dashboard usage.

A second characteristic, or goal, of BI systems is automating as many data utilisations steps and functions as possible (Ranjan 2008). Firstly, this saves time from anyone who, without BI, would work on it manually. Secondly, this enables BI systems to utilise and show real-time data (Watson & Wixom 2007), which consequently can allow decisions to base on the most current data available in the systems. Thirdly, partly due to the automation, BI tools excel in utilising large amounts of data (Chaudhuri et al. 2011), as it can be done in the background. In practice, this means that as opposed to most common spreadsheet tools, BI tools can do their data processing in the background, without using the local computer for it.

A third major characteristic of BI tools, especially the types this thesis focuses on (e.g. Microsoft Power BI and Qlik Sense), is the multidimensional perspective they offer to data. The immediate benefit is that they offer extensive tools for visual representation of data, which can help users find and disseminate the desired information more quickly than traditional, tabular, data presentations (Vessey 1991). They can also enable versatile ways to explore the data. These operations can include possibilities such as filtering, aggregation, drillthroughs and pivoting of the data according based on user selections. (Chaudhuri et al. 2011) The drillthroughs are a good example. Using them, the user can choose a particular piece of data and look at it in more detail. This type of a feature has also been proposed by Archer & Ghasemzadeh (1999) to be used in project portfolio selection tools. According to them:

> *The user should not be overloaded with unneeded data, but should be able to access relevant data when it is needed.*

Let us go through an example to clear it up. Imagine we have two reporting views for project management: a project portfolio dashboard with each project represented with simple schedule and budget traffic lights, and a single project view that shows the details of a particular project. The colours of the portfolio traffic lights, naturally, cannot tell much about the underlying successes or failures in a project, but the purposes of PPM might require a quick overview on the whole. Now, from the portfolio view, if using a suitable BI tool, the manager might be able to choose the project and view its details in the single project view. Thus, the manager can see the details behind the traffic light report, and might be able to make more sound judgments about the state of the project. This being said, it can be thought of as one report including two separate levels to look at the same data from: single and multi-project perspectives.

To summarise these different characteristics and benefits of BI in an information availability context, they are presented in Table 1.

Table 1. Business intelligence characteristics and benefits related to information availability

BI characteristic	Benefits to information availability
Data integration	• Data in one place – saving time • Easy access interfaces, such as web browsers
Automated processing	• Eliminating manual operations – saving time • Real-time data, available anytime
Data presentation and perspectives	• Visual representations of data for easier dissemination • Multidimensional perspectives to data: filtering, aggregation and drill-down operations

The table above does not present an exhaustive list of BI benefits, especially since different BI applications can provide diverse features. However, the ones presented in the table give an overview of the subject, and are the ones specifically connected with the data access and front-end aspects of BI. With the aspects in between, such as data warehousing and data mining, more benefits could be found, but as mentioned in the scope limitations of this research, they are not being explored here.

The literature does not currently address the relationship of BI and multi-project environments or PBOs at all. In this chapter, the relevant fundamentals of BI were presented, and next, the characteristics of multi-project environments will be explored to form a connection between the two concepts.

2.3 Characteristics of multi-project environments

Those main characteristics of multi-project environments discussed in this chapter are presented in Figure 5.

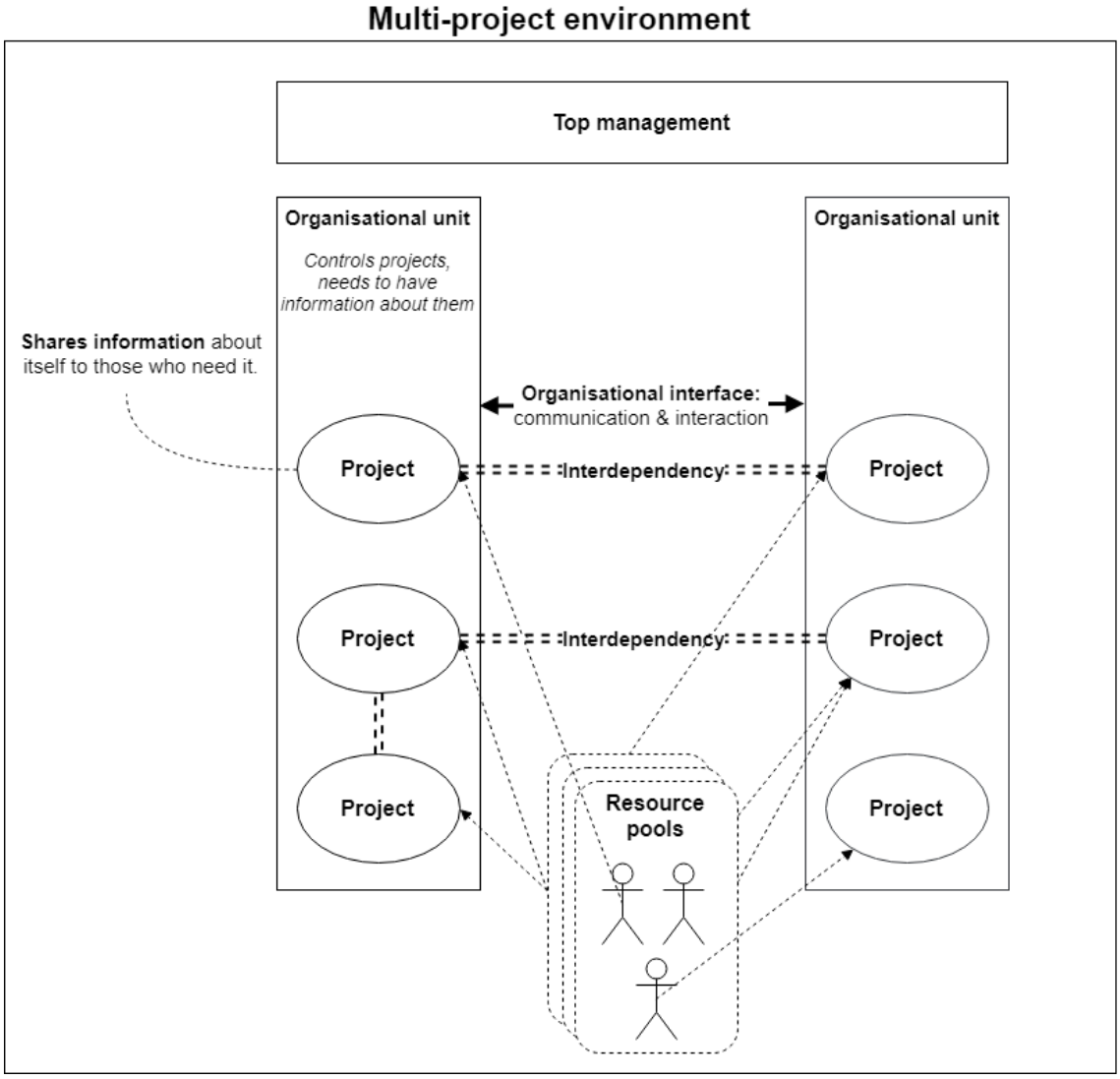

Figure 5. Illustration of multi-project environment characteristics

The figure above has been made purely to illustrate the contents of this chapter – it is not a full presentation, and a multi-project environment could be organised in various other ways. The figure shows a multi-project environment where projects are executed from the ownership of different organisational units, creating a need to coordinate actions between these units. In addition, projects interact with resource pools. These are examples of the *organisational interfaces* discussed later. The figure also shows interdependencies between projects, and the resource pools again act as an example – projects are dependent on them. These describe the *interdependencies and dependencies* to be discussed. To coordinate the multi-project management as a whole, *sharing project information* amongst participants, for example the organisational units and top management, is needed.

2.3.1 Organisational interfaces

In a multi-project environment, projects need to interact with many different internal actors, such as functional units, resource pools, top management, other projects and project

management offices (Bendoly & Swink 2007; Hobbs & Aubry 2007; Jerbrant 2013; Turkulainen et al. 2013). Project management offices (PMOs) are a bit of a peculiarity in this context, since they often facilitate interactions between the project and other internal actors (Hobbs & Aubry 2007; Jerbrant 2013). Of course, the actors a project has to interact with, and to what extent, depends on the organisation. In addition to these internal actors, projects usually need to interact with external stakeholders. These often include at least customers, suppliers, and contractors, but can also include others, such as end users, competitors, public authorities, third parties, and many more (Karlsen 2002). In accordance with the scope limitations set to the research, this analysis will focus on the intra-organisational interfaces of projects.

Project interaction with top management happens through PPM (Blichfeldt & Eskerod 2008) and other constructs, such as steering groups (Petit 2012). While PPM usually has a strategic focus, these steering groups seem to be used for more operational type of decisions, such as operational resource allocation (Petit 2012) and change management (Hyväri 2006). However, the terminology does not seem to be clear here, and these two can overlap, but this was just to present how both strategic and operational issues can be managed in the interaction of projects and top management. With the upper management interface being presented throughout the thesis using with the concepts of PPM and multi-project management, this interaction will not be inspected there more thoroughly.

As does top management, PMOs have many different ways they interact with projects, and PMO functions can differ vastly between organisations. However, some functions are more common than others, and among the most common are functions involve advising upper management and reporting project statuses to it, developing project management methodologies and tools, monitoring projects, and providing training. (Hobbs & Aubry 2007) PMOs enable activities for both upper management and individual projects, as they help both better understand and control their domain of work, and provide services for them. As such, the PMO could be considered both a functional unit specialising in project management, and an extension of upper management of an organisation.

Consider the project interaction with functional units. Many project organisations have been built in the form of a matrix, through which people from different functional areas are brought together to work on temporary tasks, projects (Ford & Randolph 1992). This results in people of different disciplines and departments being put together, and as Dougherty (1992) describes it:

> *Departments are like different "thought worlds," each focusing on different aspects of technology-market knowledge, and making different sense of the total*

A common way of this occurring is along with the changes of project phases, which is shown for example in the sales and operations interface of a project-based firm (Turkulainen et al. 2013). While marketing and sales endeavours can be seen as part of

the project (c.f. subchapter 2.1.1), they are separate phases in the project and often completed by different people. The nature of these two phases is quite different, which causes a gap between them (Cova & Salle 2005). Thus, projects pose different needs for the organisation, and not only between projects, but between project phases (Turkulainen et al. 2013). Another similar interface could be between the "execution" and "after execution" parts of the project, where the project results are moved to the customer and the supplier should be supporting the use of those results. A functional unit dedicated to providing services could then undertake the incoming phase, and the nature of these two phases can be drastically different. As Turkulainen et al. (2013) show by exploring the sales and operations interface, these type of changes could lead to knowledge gaps, such as the operations unit not adequately knowing what has been sold.

The phase changes might just cause heavy needs for interaction with functional units, but what we should focus on seems to be the differences between the interacting actors. According to Dougherty (1992), the organisational routines of these different departments rather separate than coordinate the communication, which could result in these knowledge gaps. A modern example of a separating routine, or structure, could be an information system. So, what might further stretch the gap between the departments is that they often use different information systems, too. While operations would be managed through a PMIS, sales would most likely be managed using a customer relationship management (CRM) system.

Next, let us explore the interaction between projects and resource pools. This view, can overlap with the interaction between projects and functional units, as the resource pools can be represented by functional managers (Beringer et al. 2013; Project Management Institute 2000, p. 113). However, as explained above, the interaction between projects and functional units is not restricted to resource management, so it might be useful to examine these separately. In a multi-project setting projects draw, at least some, resources from a common resource pool. As projects use the same resources, managers need to interact with each other, which may even turn into something of a competition between projects. (Engwall & Jerbrant 2003; Payne 1995) Turner & Keegan (2001) recognised two main roles in PBOs, those who drive the projects, and those who provide the resources. The primary part of this interaction is ensuring that for a project, the right people are at the right place, at the right time.

Additionally, projects interact with other projects. A crucial question in the literature of PBOs is how organisational learning is facilitated in these organisations, in which the main structures, projects, are temporary (Hobday 2000; Prencipe & Tell 2001; Sydow et al. 2004). Also, a common reason for these interactions are project interdependencies. Since these, and other dependencies, are such a crucial aspect of multi-project environments, they are discussed separately in the next subchapter.

2.3.2 Interdependencies and dependencies

Projects are interdependent when the success of a project depends on another project (Killen 2013). Naturally, this occurs in multi-project environments, and understanding the interdependencies is important, because they can affect the project portfolio as a whole (Killen 2017). As PPM is considered, for many organisations, core strategic process, managing these interdependencies can also be seen as strategy execution (Killen & Kjaer 2012). For example, as conflicts arising from project interdependencies are being solved, deliberate choices of priorities between projects are needed – and from the PPM perspective, the choices made should ideally follow the strategy formulated by the organisation.

In multi-project environments, the interdependencies come in different types and should acknowledge in the management of such environment (Caniëls & Bakens 2012; Killen 2013, 2017). Jerbrant (2013) identifies three different types of them in her research: a resource dependency, technological dependency and an organisational dependency. A resource dependency occurs when projects need the same resource simultaneously. In a technological dependency, a project is dependent on another project's intermediate or final results, meaning these projects can occur either parallel or in series. A common example of this would be a customer project depending on the result of an R&D project. The last one, organisational dependency, can occur when organisational collaboration is needed in a project activity. (Jerbrant 2013) As Bathallath et al. (2016) demonstrate, these interdependency types could be broken down even further and categorised differently, but the categorisation presented above is detailed enough for the purposes of this study.

These interdependencies are often identified in project databases and through dependency matrices. If the interdependencies are not are not taken into account, they can cause flow-on effects into other projects and affect the portfolio as a whole. (Killen 2013) These interdependencies have been a primary research field regarding information visualisation in project management, and have provided some promising results (Killen 2013, 2017). However, as Jerbrant (2013) describes, only the resource and technological dependencies are usually managed, and the resource dependency gains most of the focus, while organisational dependencies seem to not get almost any. Thus, some dependencies appear to be more easily identifiable, easier to manage, more significant, or there is some other reason why some dependencies are prioritised.

Besides project interdependencies within the own organisation, projects can also depend on a number of other things, such as subcontractor or customer schedules. And even if the source of these dependencies were located within the firm, they might not be influenceable. For example, the operation of a firm production plant might be quite inaccessible to the PBO, but projects can still depend on it.

2.3.3 Sharing project information

A project should collect information about itself and distribute it to relevant actors within and outside of the project (Canonico & Söderlund 2010). While this can be considered relevant in any organisation that uses projects, in PBOs it could be more crucial since a more significant part of the organisational information is created within projects. In terms of multi-project management success, Dietrich et al. (2002) emphasise the importance of information delivery to support decision-making, and horizontal and vertical communication. Also, distribution of the information collected in projects can enable coordination between them and facilitate the use of that information even after the project ceases to exist. For this, examples of common tools could include databases for things like lessons learned and risks (Hobbs & Aubry 2007).

As organisations shift from a single project focus to a multi-project approach, they often aim to use systemically utilise IT systems to collect data from single projects and integrate it to enable managing groups of projects (Thiry & Deguire 2007). So, while these systems (PMISs) are proved to be useful in managing complex projects, they can also be seen as a way to unify information between projects. These types of systems can provide diagnostic control, which allow comparisons across projects in terms of effectiveness and efficiency (Canonico & Söderlund 2010).

Another change that organisations often undertake when moving to a multi-project setting, is establishing a project management office (PMO), which can represent whole a project portfolio and enforce standardisation for working (Jerbrant 2013). The PMO can be seen as a knowledge broker between different levels of the organisation (Pemsel & Wiewiora 2013), and in this context let us look at the single-project level and management level. As a knowledge broker, the PMO can distribute information in both ways, to projects and to management. The information going to the projects is often project management standards and methodologies, guidance, and training, while the management uses the relevant single-project information gathered and integrated (Hobbs & Aubry 2007; Spalek 2012). Both projects and management also seem to utilise the expertise within PMOs, which for example appear as providing advice to project managers and management (Hobbs & Aubry 2007). The need for PMOs seems to show that there are plenty of needs to be addressed with communication and coordination in multi-projects environments.

2.3.4 Other characteristics

Overall, PBOs are seen suitable for situations with high product complexity, fast changing markets, cross-functional business expertise, customer-focused innovation and market, and technological uncertainty. These types of qualities make PBOs especially good at coping with change and responding to changing needs of clients. (Hobday 2000) Thus, they can provide dynamic capability through being unique and supporting innovation by

nature, but there are also strong desires to rationalise and unify project work within organisations (Räisänen & Linde 2004). Can this constant need to rationalise eat away from all that flexibility and other qualities that make projects worthwhile as an organisational form?

As projects can combine resources from different functional areas, they are by nature a global way to conduct business, at least in the sense that they can cross organisational boundaries (Turkulainen et al. 2013). Following on this, it is not uncommon that projects are also global actors in the geographical sense, combining resources from different international locations (e.g. Zika-Viktorsson et al. 2006; Turkulainen et al. 2013). In this global environment, challenges are caused by the global dispersion of units and people. (Turkulainen et al. 2013) With global environments factors such as culture, time zones and languages also play a role, even though the internet has made geographic differences less relevant.

Maybe due to all the complexities in multi-project environments, mentioned here and in previous sections, they can also be seen as highly competitive and even political (Engwall & Jerbrant 2003; Martinsuo 2013). As Pinto (2000) described it:

> *Recalcitrant functional managers, unclear lines of authority, tentative resource commitments, lukewarm upper management support, and hard lessons in negotiation are all characteristics of many project manager's daily lives. Set within this all-too-familiar framework, it is a wonder that most projects ever get completed.*

One example of where this can stem from is project managers and functional managers having conflicting interests (Laslo & Goldberg 2008; Platje & Seidel 1994), but of course, conflicting interests can exist between many other actors, too. As a result, project managers might have to compete for the resources available to their projects, or may even portray the project as higher priority than actual to get the best experts (Engwall & Jerbrant 2003).

Drawing from these thoughts, it seems there is still much to explore in the rationalisation of multi-project environments. Multi-project environments portray a picture with unclear roles, uncertainty, disagreement, and negligence, but projects are still highly favoured by organisations, and are needed despite the troubles. Engwall & Jerbrant (2003) even made the conclusion that it might be beneficial to rebuild the whole system of managerial procedures from its roots.

2.4 Critical development areas in multi-project environments

2.4.1 Overview

The most prevalent issue of multi-project environments seems to be the so-called *resource allocation syndrome* (Engwall & Jerbrant 2003; Yaghootkar & Gil 2012), which simply means the problems related to the allocation of resources between simultaneous projects. However, while the issue can be described with one term, there are many different underlying reasons that contribute to this syndrome (Engwall & Jerbrant 2003). The critical development areas recognised from the literature of multi-project management are presented in Table 2.

Table 2. Critical development areas of multi-project management

Development area	Reference	Context / methods	Related findings
Communication across organisation	Elonen & Artto (2003)	• Multi-method qualitative case study • Two internal development project portfolios	• Lack of information on projects • Inadequate flow of project information across organisation • Information flows from projects to other parts not defined • No common database of projects
	Bendoly & Swink (2007)	• Experimental research with multi-project management scenarios • 229 MBA students	• Having situational information improved work and management behaviour • Transparency can allow managers evaluate (resource sharing) options on a global level • Potentially less conflicts: motives clearer
	Jerbrant (2013)	• Qualitative case study • Two project divisions • Doctoral thesis note	• Needs for organisational collaboration between projects and line organisation not managed by PPM
	Turkulainen et al. (2013)	• Qualitative case study • 19 interviews • Three projects in detailed analysis	• Needs for cross-functional integration varies across project phase • These interfaces need to be managed, but literature suggests they are often not
Cross-project integration and management control	Hobday (2000)	• Qualitative case study • Two divisions: functional matrix and pure project-based division	• When projects have strong independence, they risk "going their own way", which makes PBO coordination difficult • Cross-project learning is supported by non-project, permanent structures
	Elonen & Artto (2003)	* already described above	• Inadequate methods and guidelines for PPM • PPM responsibilities not clear or digested
	Thiry & Deguire (2007)	• Literature review of PBOs	• Recent studies show that PBOs need to adopt integrative methods to deliver strategy and unify knowledge • PBOs are struggling to integrate knowledge and structures, projects are viewed as "singular ventures"

Development area	Reference	Context / methods	Related findings
	Bathallath et al. (2016)	• Literature review of managerial issues in information systems / information technology project portfolios	• Interdependencies between projects are often difficult to manage and not adequately addressed • Sources of problems include: insufficient inter-project learning, the absence of specialised methods, and ineffective inter-project processes
Resourcing and scheduling	Engwall & Jerbrant (2003)	• Qualitative case study • Two project divisions	• Projects lagged behind their schedules, and as a result, resources could not be utilised • Committing to too many projects in relation to resources
	Yaghootkar & Gil (2012)	• Qualitative case study • Simulation on schedule-driven multi-project management • Truck manufacturer	• Too many projects, both for organisation and individual employee • Late starts did not change deadlines, because employees avoided internal conflicts • Schedule-driven management caused resource problems
	Elonen & Artto (2003)	* already described above	• Human resource shortage, inadequate competencies (i.e. too many projects or wrong types of projects)
Project overload	Zika-Viktorsson et al. (2006)	• Exploratory research with 392 project workers, web-based questionnaire • Major manufacturing, pharmaceutical and construction companies in Sweden	• Almost one third of employees were under perceived project overload • Explaining factors: no time to recuperate, inadequate routines, scarce time resources, large number of simultaneous projects • Related to increased stress, decreased competence development and schedule deviations
	Karrbom Gustavsson (2016)	• Qualitative, 3 PBOs, 43 interviews • Engineering-intensive firms	• Multi-project work seems to be more characterised by constant changes and handling of emergency crises than planned and structured work • Project overload is result of: too many parallel tasks and too many parallel and interconnected projects in combination with constant disruptions and frequent alternating between projects and tasks

Initially, politics affecting multi-project management was recognised as one of these development areas, as Engwall & Jerbrant (2003) saw resource conflicts and the resulting politicking as one reason for the resource allocation syndrome. Still, these conflicts seem to be resulting from conflicting interests of, for example, project managers and functional managers (Laslo & Goldberg 2008; Platje & Seidel 1994). In addition, as described by Engwall & Jerbrant (2003), project managers might have to compete for the scarce resources available for their projects, which might cause this type of behaviour. Bendoly & Swink (2007) saw that information transparency could reduce the risk of these conflicts. For now, though, there does not seem to be enough empirical evidence to categorise this as a separate development area, as the phenomenon can be a plain result of inadequate management of the other development areas. In the following subchapters, the development areas presented in the above table will be presented and discussed.

2.4.2 Communication across organisation

As multi-project environments involve a variety of different actors, efficient communication between them is a challenge. Lack of timely and accurate communication across the organisation has been recognised as an issue for these environments (Elonen & Artto 2003; Jerbrant 2013). Elonen & Artto (2003) saw this as a lack of transparency in project information and its quality, and personnel not being clearly informed when information should be delivered, on what, to whom, how and in what format. Multi-project environments have, however, attempted to tackle the issue, with new organisational structures. Jerbrant (2013) recognised project management offices (PMOs) as an intermediate to communicate and coordinate between different parts of the organisation: top management, line managers, project managers, and project team members. Similarly, BI could act as the intermediate, by integrating information across the organisation, from different systems, to all users (Chen et al. 2012). PMOs do have a variety of other functions, too – they have not been constructed solely for the purpose of being a communications hub (Hobbs & Aubry 2007). However, the current research fails to address whether these needs for integrating information in the multi-project environment could be fulfilled with appropriate tools, instead of a PMO.

Issues in communication are not only about the missing information – being deprived of information affects the behaviour of individuals, possibly creating a worse work environment. As Bendoly & Swink (2007) conclude, the lack of global information visibility can have negative effects on work and management behaviour, and firms should consider mechanisms that allow sufficient transparency between project managers and resource management. While this study focused on resource management, and resourcing and scheduling is listed as a separate development area here, the information visibility would still be a communicational issue. The findings of Bendoly & Swink (2007) suggest that this information visibility could affect the future and immediate task performance, and influence the motivation and intent of decision-makers, for example by reducing reciprocal behaviour between managers. A limitation related to this research is that it was conducted as an experimental research among MBA students, so the results cannot be directly transferred to a real-life multi-project organisation. However, the study highlights the importance of information visibility from a behavioural standpoint.

Approaching the subject from a behavioural perspective might lead one to think that lack of communication emerges solely due to the unwillingness to communicate. However, organisational structures play their part in this. Turkulainen et al. (2013) found that organisations had problems in communicating relevant information between different functions, in this case the examined interface was the one between sales and operations departments of the organisation. According to them, these interfaces are dependent on project phases, and thus, the information delivery between functions would be relevant in other phases and interfaces of projects, too. Of course, which interfaces between projects

and functional departments are relevant for a project, depends on the context. For example, if an organisation conducts its development activities through a separate functional organisation, projects dependent on development results might need to interact with that function.

The correct solution to these types of issues might involve more than openly communicating all available information to those who need it. The flow of information is not enough, but the quality and reliability of the information available needs to be accounted for. Terwiesch et al. (2002) explored the possible problems and solutions related to communicating incomplete or uncertain information in a concurrent engineering context. While this research was conducted examining tasks that were parts of individual development projects, the authors state that the effects of making decisions with such preliminary information should be studied in other contexts, too. The study highlights the risks of sharing information too early, especially if the context and the uncertainty aspects are not described along the information delivery. Thus, using PMISs and BI tools to provide the most current situation of a project in an instant could also pose the risk of sharing preliminary information, which is uncertain or incomplete.

2.4.3 Cross-project integration and management control

Cross-project integration can be considered somewhat related to communicational issues, since this type of integration does involve communicating single-project information to higher levels. However, here, the scope also covers what that integration entails and how the information could be used.

According to a literature review on PBOs by Thiry & Deguire (2007), these organisations are struggling to integrate knowledge and structure, and projects tend to be treated as isolated entities. They also conclude that PBOs should seek integrative methods for better strategy delivery and unifying knowledge between projects. Similar conclusions have been made elsewhere, too. In his case study of two large projects, Engwall (2003) concluded that project work would benefit from perspectives that show the historical trajectories over successive projects and cross-section comparisons over simultaneous projects. He wants to highlight how projects are affected both by their historical and organisational contexts, and vice versa. Engwall (2003) also discusses how different types of dependencies, or project interdependencies, might affect dynamics of a project. And here, the dependencies do not limit to direct ones, such as resource or technical needs, but also things such as the tools, methods and approaches used in projects, as they are all results of an organisational continuum. As Bendoly & Swink (2007) found that openly communicating reasons for resource unavailability resulted in better performance and satisfaction, it could be hypothesised that integrative and more transparent approaches to multi-project management as would yield in benefits.

Management control is difficult to apply, if the project information is unavailable or dispersed among multiple channels. As Hobday (2000) notes in his research, this can be an issue for projects with significant autonomy, where project managers are free to choose the tools used for that project. This can lead to a situation where the management lacks ways to track and control the project, meaning the project information is virtually unavailable for them, and thus rendering the management unable to respond to changes in the project. Similarly, Elonen & Artto (2003) described a case where no central database for projects existed, making it difficult to find, access or integrate the data with reasonable effort. In other words, there was not a single point of access to that data, again making it less available, and complicating cross-project integration and management control.

While the availability of project information is essential for enabling control, the appropriate tools, methods and roles are needed to apply the control in practice. In their case study, Elonen & Artto (2003) discovered how inadequate tools and guidelines for PPM resulted in a lack of management control. BI can provide tools for integrating information and managing multiple projects, but it cannot replace the appropriate roles and guidelines in an organisation. However, as BI can be highly customisable, those roles and guidelines should be addressed in the design of BI solutions.

2.4.4 Resource and schedule planning

Failing scheduling is the most discussed reason in the literature for resource allocation syndrome (Engwall & Jerbrant 2003). And as these two planning activities are tied to each other, they are presented here together.

Often, it is difficult to say which one fails, and they should be treated as one. Assigning inadequate resources to a project is likely to result in a schedule failure, or bad conditions for employees. Yaghootkar & Gil (2012) noted in their case research, how a schedule of the most critical project was optimised while depriving other projects of resources. The schedule-driven approach lead to cycles where employees were constantly reallocated to projects that were behind schedule. The employees perceived this to reduce their productivity and happiness at the workplace, while also having to commonly work overtime. Almost no rescheduling was used, but planning relied on having no restriction regarding the reallocation of resources. In a similar manner, Engwall & Jerbrant (2003) noted how in their case research, resource utilisation seemed well-planned, but as project lagged from their schedule, the resources stopped being available for other projects, thus affecting their schedule.

The failures in planning can relate to an individual project, but still having radiating effects to other projects, or alternatively, they can emerge from a systematic error in planning. In previous literature, organisations systematically overcommitting to projects is a common issue (Engwall & Jerbrant 2003). Organisations assign themselves to too many projects, or too large projects, in relation to the resources available. Somehow, it seems

that when committing to new projects, the availability of resources is neglected. One reason for this could be found from the sales-operations interface presented by Turkulainen et al. (2013), where the sales department make the decision of committing to a project, while the operations unit controls the resources – and disturbances in communication lead to error. Engwall & Jerbrant (2003) found two different approaches leading to this issue – one organisation aimed to win all the contracts, and the other one did not have clear prioritisation rules for its business opportunities. Due to the behaviour, the researchers noted a continuous lack of resources and inadequate competencies in projects. Blichfeldt & Eskerod (2008) found that some, smaller projects were not included in the PPM processes, resulting in the resource usage of those projects going unnoticed.

While failing in planning can cause issues with following the predetermined schedule, it also a burden to the employees, and could make an organisation less efficient. In project overload, employees experience disturbances and fragmentation of work, usually due to a high amount of simultaneous projects. It can show as a constant need to switch between projects and tasks, and characterising the multi-project environment as constant stream of emergencies rather than planned and structured work. (Karrbom Gustavsson 2016) The issue seems nothing but minor, as a third of project workers from major companies in Sweden, who responded the questionnaire, were under perceived project overload (Zika-Viktorsson et al. 2006).

2.5 Synthesis

2.5.1 Information needs in multi-project environments

As the literature review suggests, multi-project environments need to handle a large variety of different types of information needs, with both internal and external stakeholders.

Projects need to share information for a variety of stakeholders, both internal and external. Firstly, a project, as a temporary organisation, needs information about itself. On this level, especially the decision-maker, i.e. project manager, needs information regarding the project life cycle. This translates to information on aspect such as project progress, completed and remaining tasks, costs and resource use. To form an accurate picture of the project status, this information is often compared to the project plan (Raymond & Bergeron 2008). Secondly, projects need to share information to other projects as interdependencies between them can occur. A project can be directly interdependent from the results of another project, or the interdependency can be more indirect, such as a resource dependency. Thirdly, projects also need to distribute their information to higher, multi-project management levels, to enable coordination of project portfolios. Then, projects may need exchange information with other organisational entities, such as functional departments or resource managers.

At the multi-project level, there are the groups of projects need to be controlled from a variety of perspectives, which can result in complex information needs. This information can include, for example, project interdependencies (Engwall & Jerbrant 2003; Killen 2017), resource use and availability (Engwall & Jerbrant 2003; Laslo & Goldberg 2008), consequences of decisions across the portfolio (Killen 2013), portfolio risks (Olsson 2008; Teller & Kock 2013) and financial expectations (Kaiser et al. 2015). Teller & Kock (2013) studied risk transparency and risk coping capacity in terms of portfolio success, and suggest that both have a direct positive effect on it. According to them, in addition to single project risks, the management should be provided a holistic view of portfolio risks to recognise effects of possible interdependencies in the portfolio. However, all this information builds up from the single-project level. Thus, to produce relevant information for multi-project management, the information needs to be first created on the single-project level and then transferred to the multi-project level. As this level integrates some of the information on the single-project level, the results could also be used to portray the status of business to different stakeholders, such as top management and shareholders.

Other organisational levels also both produce and require relevant information in multi-project environments. Information on higher levels can be needed across functions, such as between the sales and operations interface. As an example in this context, the sales organisation needs information about the operative capabilities of the operations organisation, including resource availability (Turkulainen et al. 2013). This is an example the information cannot be retrieved from projects, since projects, generally, do not control the resources or are in charge of their availability. Rather, in multi-project environments, projects draw resources from common pools (Engwall & Jerbrant 2003; Fricke & Shenhar 2000; Payne 1995), and it is often the functional manager who is responsible for coordinating human resources for the projects (Beringer et al. 2013; Project Management Institute 2000, p. 113). This non-project level producing information is crucial here, since we have to acknowledge that not all internal data relevant to projects is produced in projects. As the issue with resource and schedule planning were previously noted as a development area for multi-project management, this type of non-project data has at least one important use.

While the above considerations have been constructed using a general view to multi-project environments, the first research question was context-specific: “How could business intelligence be used to support multi-project management *in the case organisation*?“ Thus, it should be also considered if this environment could have specific information needs requiring emphasis. The environment emphasises delivery projects, and development projects are often executed as parts of them. Thus, dependencies between projects and communication between them might have a greater role. Since the development projects can be executed through a different organisational entity than delivery projects, in addition to the sales-operations interface described by Turkulainen et al. (2013), other

similar organisational interfaces could prove significant sources of information. Additionally, as the traditional PPM view focuses on development projects (Elonen & Artto 2003; Tikkanen et al. 2007), that point of view might not be fully applicable in this context. As even development projects in the context often contribute directly to the needs of a specific customer, the most significant PPM decisions could be made at the sales phases of projects. Thus, strategic information needs could be more crucial at the early phases of projects, while the latter phases would focus on efficient project execution.

2.5.2 Potential of business intelligence to support multi-project environments

As concluded previously, BI offers many potential ways to improve information availability in an organisation. However, these presented benefits are general, and currently the project management literature does not seem to address the potential of BI in project management almost at all. Multi-project environments seem to, though, have a general need to share information with a variety of different stakeholders. Thus, BI seems like a solution that could have a lot to offer in this context. The potential uses of BI benefits in relation to previously presented multi-project management development areas are presented in Table 3.

Table 3. Potential uses of business intelligence benefits on multi-project management development areas

BI characteristic	**Data integration**	**Automated processing**	**Data presentation and perspectives**
Multi-project mgmt. development area	Potential uses in multi-project environments		
Communication across organisation	Integrating data across organisation. Utilising BI as a central sharing platform (i.e. visibility to projects from organisational units)	Enabling real-time, anytime data availability across organisation Providing an automated channel for information flow	Providing multidimensional views to project data (i.e. ability to examine portfolios and individual projects in them)
Cross-project integration and management control	Aggregating single-project data to present views into portfolios, e.g. interdependencies Integrating project data from different systems	Real-time, anytime views on portfolios → monitoring and finding deviations	Multidimensional views to access single-project information through portfolio dashboards
Resource and schedule planning	Providing resource use data across the multi-project environment, for a holistic view on, e.g. resource availability and loading	Automatically highlighting schedule and other deviations causing problems in initial plans	Allowing managers to find and connect problems in planning different levels (e.g. portfolio, single-project and functional levels)

As the use of BI in multi-project management has not really been studied in the literature, the potential benefits of BI in this context are hypothetical. Due to this, the possible solutions are also only examples of how BI could be utilised in a multi-project context. Also, no comparisons can be made regarding how effective these types of solutions could actually be in relation to more traditional means of reporting. The main connecting factor of these solutions and the presented development areas is the fact that the particular development areas are on some level connected to the availability of information in multi-project environments, and BI has a variety of ways to tackle the issues of information availability.

There are also a multitude of factors that could interfere with the utilisation of BI in these environments in practice. For example, organisational factors could be relevant. Willingness for multi-project environments to adopt new tools, BI solutions, in their operations could affect the success of the system. Utilisation of these types of tools could be affected by the ease of use and information quality, among other factors (Ali et al. 2012). Related to information quality, as one of the benefits of BI is information timeliness, and the systems still need data input from humans, a limiting factor could be whether those inputs are sent to the systems in a timely enough manner to actually support the availability of real-time data. Additionally, reaching an adequate level of data accuracy and completeness could be a challenge in a shift from traditional reporting to BI solutions. Compared to traditional reporting, the BI systems explored here rely more on quantitative data, as aspects such as data mining are excluded from the scope of the research. If the quantitative data by itself cannot provide an adequately comprehensive view on a project, the systems might still need support from other types of reporting. While even qualitative data could be programmatically analysed with using data mining or text analytic engines (Chaudhuri et al. 2011), these types of tools are not in the scope of this research, and could be difficult to justify with the relatively low amount of data a multi-project environment is usually able to produce.

3. RESEARCH METHODOLOGY

3.1 Research design

This thesis uses the research strategy of case study. According to Yin (1994, p. 13), case study is an empirical enquiry that

> *investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident.*

Following this definition, the contemporary phenomenon investigated in this thesis are the processes of multi-project management, especially those related to reporting and communication. The real-life context then, is the case organisation. The multi-project processes investigated can described as highly bound to the context: a different industry, organisational structure or culture would most likely result in different observations. Thus, the case study seems an appropriate research strategy choice for this study. As the research concerns only the case organisation as a whole, while not examining the logical sub-units of the organisation separately, it can be further described as a holistic case study. The case study strategy can be considered a useful way to explore the existing theory on the subject. (Saunders et al. 2008, p. 147)

Since the aim of the research is to thoroughly understand and find underlying needs from this environment, using a quantitative data collection methods could result in a comparatively shallow description of the subject (Saunders et al. 2008, p. 482). Thus, this research will use qualitative methods to provide a deeper, more comprehensive view of the subject.

This research combines both descriptive and exploratory elements in terms of research purpose. Firstly, the research aims to understand and identify the multi-project management practices in the case organisation. This part is descriptive, and descriptive research can be a forerunner to exploratory research (Saunders et al. 2008, p. 140), as it is here. As supporting multi-project environments with BI tools is something not previously extensively explored, the thesis takes an exploratory approach while trying to find out if those tools could support this type of an environment and how. Also, as no predetermined theories or frameworks will be tested in this research, and the study moves from observations to generalisation, the research approach is inductive (Saunders et al. 2008, p. 61).

It should be noted that in this study, the researcher is simultaneously a practitioner in the organisation, which may impair the ability to examine the environment objectively. Resulting from this, the research also has some elements of action research, such as the close involvement in the development of the organisation, but it is missing the iterating nature of action research (Saunders et al. 2008, p. 148).

3.2 Case characteristics

The case organisation delivers industrial machinery on a global scale, executing tens of customer delivery projects simultaneously. These can vary significantly in size and complexity, as largest projects have sold for tens of millions of euros, while small projects can be in the scale of some 100,000 euros. Largest projects are prioritised higher than the smaller ones, include more complexity, can have multiple project managers for different parts of the project, and often involve significant portions of development work.

Development activities are often conducted directly for to be used in a delivery project, which creates interdependencies the delivery and development projects. In addition, those developmental aspects of a project are largely determined at the sales phase, which is one more factor to consider. However, the development projects are often modular, and can be used to develop a new feature for a particular customer, while utilising the results of previous development projects in the core of the product.

Between the delivery and development projects two worlds clash. The core of the delivery projects is the traditional, heavy machinery. Simultaneously, software and automation are at the centre of development activities, and their significance continues growing in the industry. While development activities in the organisation are more than software, it is a great example of the heterogeneity of projects in the organisation. Software development in the organisation is mostly centralised within one unit with its own methods of working, starkly from the rest of the organisation.

Despite the differences between projects, organisational units and methods of working, the different projects need to be coordinated together. The viewpoint from which this thesis looks at the environment, bases on BI and reporting. However, the environment is also highly complex, which is why a major part of this study is dedicated to understanding the organisation and its activities. Through creating a thorough understanding of the environment, the study aims to find how this BI and reporting viewpoint could be applied to benefit the organisation, and to develop solutions for better multi-project management.

3.3 Data collection and analysis

The qualitative primary data for this thesis was collected using two methods. Firstly, the employees of the case organisation were interviewed. This was the most important data collection method of the thesis. The other method was a research diary, which was meant to complement the data collected via interviews. While a research diary could be used as an introspective tool to guide and observe the research process (Nadin & Cassell 2006), here its main purpose was to record the relevant meetings the researcher attended in the course of the research process.

As a source of secondary data, the databases of the case organisation were used. These provided content such as process descriptions, minutes of meetings and old reports. However, no structured analysis process was used to disseminate information from them, but rather, this data was sought and used whenever it was needed as a part of the writing or analysis processes.

3.3.1 Collection and analysis of interview data

For interview data collection, semi-structured interviews were used, interviewing employees of different organisational levels and roles. The aim of the interviews was to produce an encompassing view on project management practices and issues, project management metrics, current reporting procedures and future needs, decision-making, and use of PMISs in the organisation. Some of the elements of the interview structure, such as the project management metrics and future needs, were adapted from the Kerzner's (2013) book *Project management metrics, KPIs, and dashboards: a guide to measuring and monitoring project performance*, which provided insights on how project management dashboards could be built according to user and organisational needs. However, the interview structure as a whole did not follow any established framework, but reflected the researcher's experience on what would be relevant to the research, thus taking an inductive approach to the subject (Saunders et al. 2008, p. 61) The interview structure is presented in Appendix A.

To gather the data, nine employees were interviewed. The interviews were conducted during September and October 2018. In all of the interviews, the researcher was the interviewer. All of the interviews were conducted in Finnish instead of English. As all of the interviewees were native Finns, choosing Finnish was seen as a way to achieve discussions not restricted by a foreign language, making them also more natural.

The interviews were recorded and transcribed. Most of the transcription was done as verbatim transcription. However, not everything in the interview recordings was transcribed, but only those parts that were seen, even remotely, relevant to the research. Additionally, some parts known not to be usable as quotes, were written as notes. Thus, this was the first step taken in the analysis of the interview data. This type of "filtering" was a form of heterogeneous sampling, with the intent to focus on the key areas of the research. Heterogeneous sampling can be seen as a useful method in describing and explaining key themes observed. (Saunders et al. 2008, p. 239) After transcription, the data was categorised in Microsoft Excel using the interview question categories (see Appendix A), excluding the general categories of background and example projects.

The interviewee selection emphasised having people with various backgrounds provide their views on the subjects. In addition, an important criteria for the interviewee selection was that they (and other people in similar roles) would be the users or stakeholders of the

future reporting platforms. The information on interviewees and interview durations are shown in Table 4.

Table 4. Information on interviewees and interview durations.

Person number	Current position	Organisational level	Duration (h:mm:ss)
1	Senior manager, project operations	Senior management	0:54:41
2	Business controller	Middle management	1:08:38
3	Director, software engineering	Senior management	1:14:56
4	Vice president, solution sales	Senior management	0:57:22
5	Project director	Senior management	0:53:12
6	Project engineer	Worker	0:57:20
7	Project manager, R&D	Middle management	1:26:54
8	Vice president, product line	Upper management	1:07:36
9	Senior manager, R&D	Senior management	0:59:04
		Average time: 1:04:25	**Total time: 9:39:43**

As can be seen from the above table, most of the interviewees were from the senior management level, but all of them represented different types of work environments. Only three of the nine interviewees were middle management or lower, which means the gathered data can be biased towards multi-project management. Partly due to the various backgrounds of the employees, the interview structure was not strictly followed for each participant. For example, the interviewee in the position of a business controller dealt with projects heavily leaning towards a financial perspective, so asking about PMISs or deeper reasons for project success would probably not have led to any major insights. Thus, as questions related to certain fields of expertise led to nowhere fruitful, the researcher tried to find the areas worth discussing and proceeded emphasising them.

3.3.2 Collection and analysis of diary data

A research diary was used as a data collection method. Even though the research diary as a data collection is can be seen as a tool for reflection (Nadin & Cassell 2006), here the main purpose of the diary was to record interaction, mostly meetings.

Notes were made in the meetings and sometimes reflected on afterwards, and also the dates, agendas and participants of those meetings were recorded. However, as the researcher attended those meetings as a participant, rather than a mere observer, the quality and extent of note writing varied. Things perceived important at the time gained more attention, and intense discussions might have left little room for note writing. The researcher cooperated especially closely with three people in the case organisation, due to the natures of their work and personal interests in the subject of the research. These people are listed in Table 5.

Table 5. People of close cooperation

Person number	Current position	Organisational level
10	Senior manager, project performance	Senior management
11	Resource management solution owner	Middle management
12	Senior manager, professional services	Senior management

What is notable from the people presented in the table is that they are all employees not controlling individual projects, but rather supporting a multitude of projects. As mentioned, the emphasis on the diary was placed on meetings, and a summary of the meetings is presented in Table 6, which also shows the attendance of the mentioned people in the meetings.

Table 6. Summary of meetings

Date (yyyy-mm-dd)	Generic title	Duration (hh:mm)	Attendee person numbers	Number of other attendees
2018-04-06	Initial meeting	00:50	11	
2018-04-06	PMIS situation check up	01:00	10,11,12	
2018-04-13	Technical review	00:50	11	1
2018-05-21	Progress check up	00:50	11	
2018-06-07	Report requirements	00:30	11,12	1
2018-06-29	Report requirements	01:00	11,12	
2018-07-19	Report requirements	00:30	10	
2018-08-01	Report review	01:00		1
2018-08-10	Progress check up	00:50	11	
2018-08-17	Report requirements	01:00	10,11,12	
2018-08-27	Report requirements	01:00	10,11,12	1
2018-08-31	Report review	01:00	10,12	1
2018-09-10	Report requirements	00:50	11	1
2018-09-26	Report requirements	00:30	10	
2018-10-08	Report review	00:30	10	1
2018-10-10	Technical review	01:00	10,11	
2018-10-11	Report requirements	01:00	10,11,12	
2018-10-19	Report requirements	00:50	11	
2018-10-22	Technical / requirement review	01:00	10,11,12	3
2018-10-23	Technical review	00:30	10,11	2
2018-11-12	Report requirements (product line)	00:30		1
Grand total		**17:00**		

As can be seen from the table, the meetings addressed, for the most parts, the requirements of the future reports. Thus, as opposed to the interviews, the meetings did not focus on project management on the general level, but their agendas were usually about certain,

even already agreed on, reports that should be generated. The participants often had a special interest on the reports, and needs that were already refined to the point where the content of an individual report could be discussed. Needs were reviewed and technical capabilities and next steps of report development planned. These things being said, the data gathered from these meetings could be directly used to determine what types of reports would be required in the case organisation and what information should be presented in them. This data could then be utilised, with only little adjustments, to draft the reports to be presented as a result of this thesis. Thus, this data is a major direct contributor on the results of this study, while the previously addressed interview data focused on more general issues of the subject area.

The table also shows how the mentioned people of close cooperation attended these meetings. There are only two meetings which none of them attended, so the data gathered from these meetings is almost certainly biased towards their opinions of the subject matter. However, these people were also the main stakeholders of the reports being developed, and had keen interest and expertise on the subject.

For analysis, the research diary notes were collected in one text document and the data was categorised into report type needs, report content needs, technical requirements or challenges, and other findings. Since the researcher attended the meetings, it should be acknowledged that an important part of the analysis was done in the cognition of the researcher. For example, the importance of different report needs have gained their perceived importance throughout the process, and the research diary notes do not address this. The role of the note writing has, above all, been a memory aid for the researcher. With these notes, the researcher has been able to recollect how the importance of certain areas of the subject have been emphasised in the meetings and discussions.

3.4 Other empirical data

Various other data sources available to the researcher were used to complement the primary collection methods. These are presented in Table 7.

Table 7. Other empirical data sources

Data source	Types of data
Organisational process and structure content • Project management process descriptions • Organisational charts	Slideshow presentations, text documents, diagrams, various types of intraweb content
Minutes of meetings, presentations • Project management development plans • Steering group meeting presentations and notes • Project status reports	Slideshow presentations, text documents, spreadsheet content
Reporting tools, report templates	Spreadsheets and presentations

These data were not used or analysed in a structured manner, but they were used as complementing material. A usual situation where the researcher resorted to this data was when some fundamental data about the case organisation was needed, for example formal process descriptions or organisational structure. The data was also used to complement the primary data sources. For example, if an interviewee described a certain project or a meeting type, but the researcher did not feel he had adequate initial knowledge about the subject when conducting analysis, the needed information could be found using the organisational databases.

3.5 Using the data and structuring the study

Starting with the interviews, after they had been done and data categorised, the interview questions structure did not seem optimal for presenting the findings. While then interview structure was initially aimed to support the formulation of the reporting frame (i.e. needs and types for reports and information), the interview data turned out to describe the multi-project environment of the case organisation on a more general level than expected. I suspect that this was due to the reasons below:

- It seemed easier for the interviewees to discuss their personal experiences, rather than abstractions such as reporting and data,
- Interviewees came from different organisational levels, (and thus had a variety of views to reporting and project management, single; multi) and (had to be generalised)

Due to the abstractions being difficult to discuss, interviewees tended to describe especially decision-making, project management, metrics, and information needs through the problems and situations they had had in the past. While this, in retrospect, should have been no surprise, it led to more high-level perspectives. For instance, most decision-making was not seen as decision-making per se, but most often as plain communication. Thus, this communicational view will be used to structure in the empirical part. Metrics and information needs, on the other hand, took the discussions to how projects are actually managed, and often emphasised, depending on the interviewee, either single-project or multi-project level. This was mostly dependent on the organisational level or position the interviewee was in. As the interviewees came from different positions, often the questions needed to be followed up with more general-level inquiries, in case the topic was unfamiliar or too specific to them. Due to these reasons, the findings could be better presented through categorising them into single-project management, communication and multi-project management.

In the interview structure, there was also a category for data and information systems, which was easy to discuss, and is being used in structure of the empirical part. The “dashboards and reports” part of the interviews, however, did not yield the exact information that it was intended to. This was partly due to formal reporting not being used that much,

especially on the single-project level. Many interviewees did, though, have ideas and views directly about how BI could be utilised in their work, which is why there is a separate subchapter on the views regarding BI development dedicated to these thoughts and advice.

As already implied, the research diary data was significantly less general as compared to the interview data. While the interview data could be used to describe the multi-project management landscape of the case organisation in an overall manner, the research diary provided data mainly on report requirements, feedback and needs. Thus, the research diary data contributes directly to the end result of the study, the reporting frame. As the data was still based on meetings and discussing, some overflow onto the more general parts of the study expected, as people tend to describe a variety of issues regardless of the initial meeting or discussion agenda.

Through the considerations presented in this subchapter, the structure of the results of thesis is presented in Figure 6.

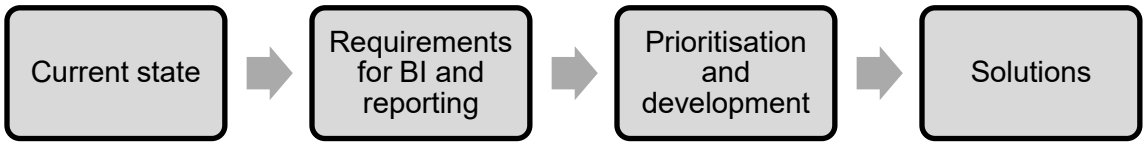

Figure 6. Structure of the results

Referring to the figure, the current state of the case organisation is first presented, focusing on the elements described in the above paragraphs: project management, communication, information systems, and multi-project management. Through analysing the characteristics of the organisation using these themes, the organisational requirements for BI and reporting are constructed. These requirements are then further prioritised and the form of the reports is being developed. Last, the solutions, including plans for further development, are presented.

4. CURRENT STATE OF THE CASE ORGANISATION

4.1 Single-project management

4.1.1 Project types

The organisation categorises its projects into customer projects and development projects. The project management guidelines of the organisation include different models for the two project types. In the formal process descriptions, the main difference between the two is considered to be whether the customer is involved in decision-making or not. The formal processes of these two project types are presented in Figure 7, with the differences in the processes being highlighted with red colour.

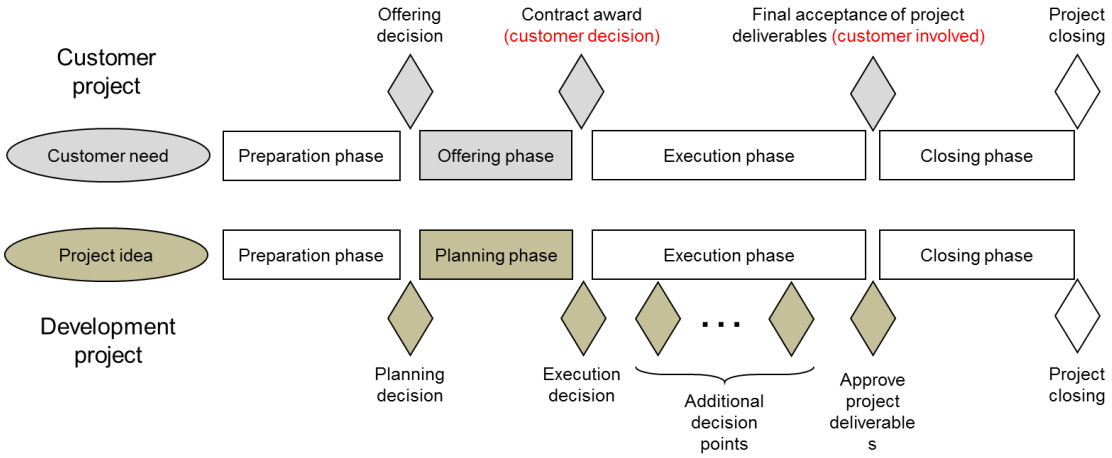

Figure 7. Customer and development projects: formal processes

As can be seen from the figure, the main differences in the formal processes are customer involvement and the additional decision points in the execution phases of development projects. These decision points can result in Go/Kill/Hold decisions as described by (Cooper 1990) or other changes to plans.

However, in reality, these formal processes seem to not apply in many cases. One interviewee described the relation of the formal development project process and reality as follows:

> *First the concept, then the product development and not until after that should we sell. How it's done in practice, quite much contradicts with the official process. - Director, software engineering*

Another interviewee complemented the comment and described the reality of the process as follows:

> *Quite typically our product development projects are related to a sold customer project, so project requirements and expectations come from there [customer projects], also schedule requirements come from there. - Project manager, R&D*

The situation is pictured in Figure 8. In the figure, the brown chevrons represent the flow of the processes regarding how the organisational guidelines address it. The arrow shows the change that has happened in this relationship, as a step in the original development process has become a step in the delivery project.

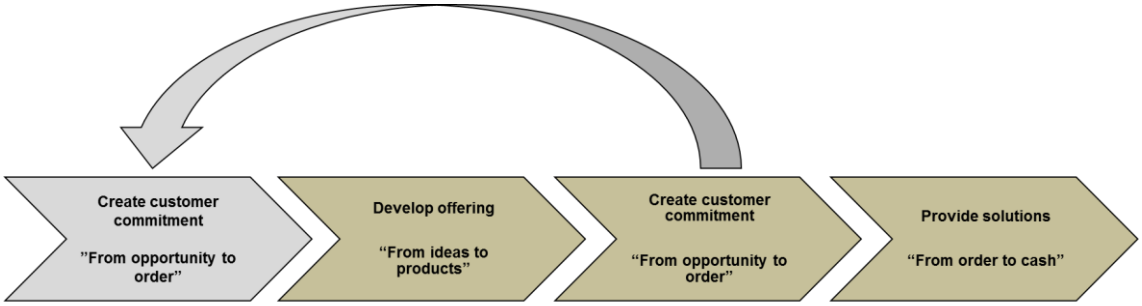

Figure 8. Change in the relationship of customer projects and development projects

As can be seen from the figure, customer commitment is many times created before the offering has been developed. This means that the project can already be sold, when the related development project is being started. Then, these development projects that are conducted to fulfil direct customer needs, do not often follow the laws of "pure" development projects, as they cannot be aborted or suspended. As an interviewee described it:

> *Those activities related to customer projects, they cannot be suspended. - Project manager, R&D*

Resulting from these observations, the development projects can actually look like something presented in Figure 9.

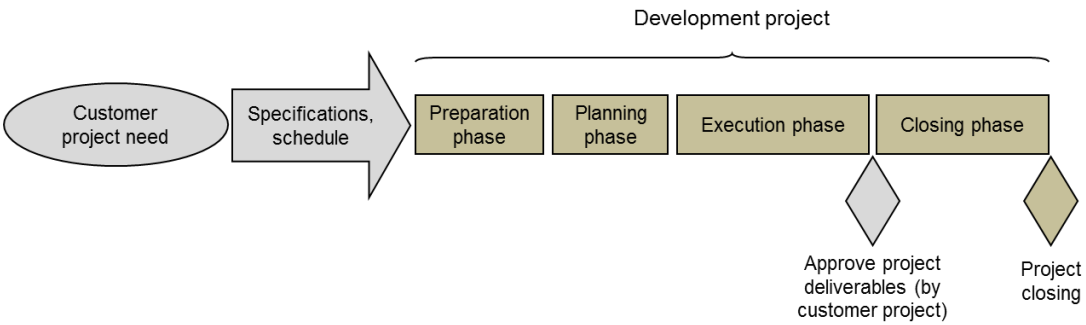

Figure 9. Possible reality of development projects in the case organisation

As illustrated, development projects can lose a lot of their autonomy due to this phenomenon. Still, development projects in the organisation are quite often started without the initial customer involvement, but tend to get more attention once the customer commitment has been established, as described by an interviewee:

> *Quite often we have something ready, a vision of the product, and the product development is starts in a serious manner when we get the final specifications for our project [from the customer]. - Director, software engineering*

So, these notions are not to imply that development projects in the organisation are conducted only to respond to direct customer needs, but rather that the nature of these projects differs between each other, and they can have different levels of autonomy and customer involvement. These projects are conducted by separate R&D sub-organisations, which try to make the project results generalisable to make them usable for multiple customers and projects.

In the organisation, the difference between a customer project and a development project is quite fickle, or at least there are strong interdependencies between customer projects and development projects. Still, the projects are implemented by different people depending on the project type, and the developmental organisational parts act as kind of contractors for the customer projects (or for sales projects, before the project is sold).

So, customer projects are obviously dependent on development projects, but for some issues, the customer projects might need to take on tasks that are perceived as job of the development domain, as described by an interviewee when talking about equipment commissioning:

> *What was the problem with these [projects], was that when we started delivering these [machines], there were no proper instructions for like, commissioning. In fact, we have been asked from the development side that we should make these type of instructions. I think it's just wrong. It's like if I bought an operating system from the store, and Microsoft would say: "Okay, now tell us how it's installed." - Project engineer*

In this case, the delivery project did in fact create the commissioning instructions for the machines. Thus, it seems that in the dynamic between these two types of projects, it can sometimes be more convenient to create the needed outputs within the own project, even though the other project was responsible of it. As the two projects here were conducted through separate organisational entities, escalating this responsibility issue could have been too much of a burden when compared it to the amount of work required for the actual task.

The reason why these two main project types and their relationships have been discussed here in such an extensive manner is that the dynamic between seems to create interdependencies between the projects. Managing these interdependencies, though, does not seem to be as fluent as the organisation wishes. Firstly, one reason for this might be the fact that interdependent projects can be pursued through separate sub-organisations, which can hinder communication. Secondly, the nature of development projects have evolved in the last few years, which has also changed the interdependencies and the organisation has yet to react to that change.

4.1.2 Project management

In the case organisation, project managers have high autonomy within their projects. The projects are issued with risk reserves, which the project managers can use to make decisions independent from the parent organisation. At least in some parts of the organisation, the high autonomy also enables better cooperation, and "natural" prioritisation of the projects, the sort of reciprocity Bendoly & Swink (2007) discuss. When asked a product line vice president if he is always present in project prioritisation decisions, he responded:

> *I have noticed that project managers can also agree [on prioritisation] with each other. … The normal boundaries, reserves, in projects are enough so that you can play it between the projects a bit. - Vice president, product line*

The interviewee also saw it useful that these project managers had many concurrent projects for themselves. This way, they had to prioritise between those projects by themselves anyway, and thus, prioritisation comes to these people naturally. Because of this, the project managers were seen also as more eager to prioritise projects in co-operation with other project managers.

When decisions that would surpass the dedicated reserves are made, authorisation from management is needed. Schedule changes are often these types of decisions, since prolonging a project often causes cumulative costs that flow through the organisation. Also, schedule changes often affect the point of time in which revenue is recognised, which can be crucial for a publicly traded company.

The amount of management control seems to vary between projects – large or otherwise special projects are under much closer inspection than standard deliveries. What drives the control though, is revenue and its timeliness. Especially customer project handovers are important to the organisation, since that is when revenue should be recognised. Recognising revenue at the forecasted times is crucial due to the reporting needs resulting from the demands placed on a publicly traded company. An interviewee described how uncertainty regarding handover phases can escalate, since they create a lot of pressure for the publicly traded company. In this example, a person responsible for the final commissioning of a delivery gets into the locus of action:

> *It's usually some maintenance person, and we try to reach him/her, and it's like almost the CEO level people who try and call him/her. But that just describes what an effect it [the handover] has and when the guy is getting the machine up and running, the significance of that throughout the organisation is tremendous. - Vice president, product line*

To conclude, the projects in the organisation generally have a high level of autonomy, and project managers are trusted. However, especially for important projects and certain phases of projects, the control relies less on the shoulders of the project manager. Thus, not all projects are equal, and deserve equal attention. Prioritisation is required and practiced.

4.1.3 Project environments

The case organisation operates globally. Even though the organisation itself is located mainly in Finland, a vast majority of projects deliver their results elsewhere in the world. This means the project management operations are centralised in one location, while the actual operations can take place around the world. These details shape the project environments the case organisation operates on. The environments are discussed below from the viewpoints of customers, collaboration and locations.

Customers. The customers of the case organisation are highly heterogeneous: they value different types of interaction and solutions. For example, automated solutions might not be the way to go in many parts of the world, as labour can be relatively affordable. Thus, the organisation has to highly diversify its offering between different customers. Also, cultures are different. Automated solutions might not be valued by the societies of different areas, since they reduce the amount of manual labour. Due to this, the company might not want always to place emphasis on automation, and might have to hide the intent to automate ports.

As customers are heterogeneous, so are their lifetime values. Thus, project prioritisation is highly dependent on the customer: some are more frequent buyers, some have great future buying potential, some are perceived as difficult partners, and so on. For example, customers know that the case company is publicly traded, and on certain occasions can take advantage of this by issuing extra demands by the end of the quarter or month, when the company should report its revenues forward to stockholders. Whether project revenues realise now or in the next month, can thus be crucial to the case organisation, and customers can affect that through whether they accept the project deliverables or not. An interviewee described how this process might realise at the customer site:

> *It's the commissioning people who always run after the customer with the [handover] documents, and they show a pen and then the customer plays that game again where they don't have a pen or "I won't sign anything before you fix those things.*

> *And I know you need these for September but we want you to fix that first and then we'll see if the signatures come or not". It's a game like that. - Vice president, product line*

Also, the progress of the sales process is hard to forecast in the industry, as the direct customers of the case organisation often cannot make the purchase decision by themselves. The direct customers are usually port operators, which are dependent on the decisions of their customers, the owners of the ports.

Collaboration. The activities of the case organisation revolve around project management. Activities not among the core competences of the organisation, are often completed using external contractors. For example, "standard" engineering and documentation is often given to contractors, with which the case organisation cooperates closely. One notable contractor, or a partner, is a joint venture with the parent company and an industrial manufacturer. For example, this joint venture can produce the standard hardware used in project deliveries, while the case organisation works to integrate and configure the automation components to them to fit the customers' needs.

In one example project that an interviewee discussed about, the case organisation had to take over the project lead on a project that was originally fully under the control of the joint venture:

> *The decision was that we would come along. It was fully the joint venture's project, but the customer was not satisfied. - Project director*

Resulting on this, the project manager was changed. Indeed, often the case organisation does not seem to see the joint venture as a highly trustworthy and diligent partner.

The parent company also owns a manufacturing plant in Europe, and the case organisation makes orders to that plant to use the hardware they produce in its own deliveries. These types of arrangements cause some degree of uncertainty to the business, since project deliveries are then also highly dependent on progress in other organisations, the operations of which can be difficult to influence directly. The case organisation has to try and forecast the progress of operations in these, but the organisational barriers can make the most current information hard to get. These arrangements cause barriers to transparency, as not all information is to be trusted in the hands of actors outside of the case organisation. Also, some activities in the customer project deliveries are handled by front line organisations, which might not have very close ties to the case organisation. Due to this, transparency between front line actors and the case organisation might have to be limited.

Locations. The global operating environment with its myriad of locations affect the projects in a variety of ways. Different locations pose different risks, laws, safety regulations, taxes, and so on. Travelling is common for employees, especially those employed by de-

livery projects. From a communicational viewpoint, that and time differences cause challenges. Different also locations naturally also bring about the need to deal with possible cultural and lingual issues.

Concluding this sub-chapter, the project environments in the case organisation can vary significantly between each other. Some customers are easy, others more demanding. Some rely largely on external collaboration, some can be done in-house. And as projects are delivered globally, they face different and varying amounts of challenges due to that aspect. This is not a comprehensive presentation of the factors present in the project environments, but it can be summarised that they vary significantly. Thus, there might be no "one-size-fits-all" solutions when aiming to improve the project management processes in the organisation, but flexibility is required.

4.1.4 Project success

When asked the interviewees how they define project success, almost everyone instinctively gave out the "iron triangle" – budget, schedule, scope – as the answer. Thus, the traditional project management values seem to be deeply rooted in the organisation. When asked to describe some other ways, outside of these three, to describe a successful project, again, almost everyone mentioned customer satisfaction in some way or another. One interviewee also expanded on this a bit, saying the satisfaction should also lead to more sales from the customer:

> *The customer has their own "tough three" in their procurement side, and if they don't quite match [with ours], then it can lead to a situation where we think we've had a successful project, and the end result is a pissed off customer that won't buy from us ever again. Then, I can't be very satisfied that budget, schedule, scope requirements realised, so it's definitely the next sale that's going to determine how successful the project was. - Vice president, product line*

These types of answers indicate that the employees, while still having a strong connection with the single-project success factors, want to look further and think of the implications of a project in the long run. As one interviewee explained:

> *It's important that we get good references, the customer gets a machine they want, the image they get from our work is good. ... Everyone has a good feeling in the project, if we go to these soft values. - Senior manager, project operations*

> *The mutual feeling of success in a project. - Vice president, product line*

One of the things that stemmed from these discussions were reference projects:

> *We also have reference projects in which we can't stick to the budget or make losses. Kind of done as references to get future projects. - Project director*

The interviewee explained how, even though it was self-evident that a project was a reference, its budget still based on the sales budget:

> *Well, it would be easier, that "hey, this is a reference project, it has been sold on a loss", so it would be immediately clear. That we wouldn't just make up a 10 % profit margin [target], when in reality everyone knows it's going to be minus 15 %. - Project director*

Thus, the case organisation does not seem to, at least consistently, account for the value of a reference in terms of budgeting. This kind of thinking could potentially skew the reality when comparing projects with each other, as the reference value only exists in the minds of employees and is not quantified. Then, those reference projects are difficult to compare against other projects, as their budgets will not hold, but no one is aware, or have different views, of exactly how much budget exceedance is acceptable.

To conclude, aside from the iron triangle, the organisation seems to value their customers, being able keep them as customers and gaining recurring sales from them. This customer importance, for now, does not seem to transfer well into quantification of the projects. With the aim of increasingly measuring projects, and of automatising those measurements with BI, it might be essential to account for these types of factors somehow. For example, let us imagine a simple project portfolio dashboard with cost indicator traffic lights. With the current data, all reference projects of the case organisation would most likely be displayed as red, and no insight on the actual state of those projects would be received.

4.2 Communication

4.2.1 Overview on meetings and decision-making

While the interviewees did not bring up that the amount of different meetings in their schedule would be too high, basing on the observations made by the researcher, meetings can be considered a major time consumer in the organisation. In a discussion, though, the manager responsible of project performance improvement in the case organisation expressed an implicit concern about this:

> *The reason why we have so many meetings might be that our reporting is not in order. – Senior manager, project performance*

Currently, it seems that having many meetings is considered as a necessary part of the operations. An interviewee acknowledged that the amount of different communication channels in the organisation is high, but did not feel raise any specific concern about them:

We have quite many communication channels, different systems, different meetings, from which you have to join the information … There are always so many communication channels. It's like the nature of project management that you have to aggregate information from here and there and know how to filter it. - Project manager, R&D

An overview of the different meetings and decision-making situations in the case organisation is presented in Table 8.

Table 8. Summary of meetings used for decision-making and communication in the case organisation

Decision making and meeting situation	**Description / content**	**Time**
Internal steering group meeting (ISG)	Going through projects in a structured manner. Escalating possible issues to the management.	Periodical, once a month.
Project specific steering group meetings	Presenting issues that need immediate attention to the steering group.	Called upon need by the project manager.
Portfolio reviews / management team meetings	Strategic decisions, directional decisions	Periodical, depending on the sub-organisation. For development projects, structured portfolio reviews are conducted, as the development organisation has the appropriate tools.
Team meetings	Status updates, personal issues, project issues	Periodical, depending on team. Often once a month.
Functional status reviews	Many different viewpoints: development project statuses, production statuses, shipment statuses	Depending on the type, usually periodical, e.g. weekly for production and shipment statuses
Project milestone and gate reviews	Which milestones need a formal review depends on the project complexity. The more complex the project, the larger part of the milestone reviews have to be formal. Also, complex projects require more stakeholders to be involved in milestone reviews.	According to project progress
Customer meetings	Informing the customer of project status and needs, addressing technical issues, making changes to plans if needed.	Can be ad-hoc, can depend on contract, can be periodical. Needs base on project complexity and customer wants.

Not many of the meetings and decision-making situations presented in the table follow a formal guideline in the organisation. This, however, should not be taken as an issue, but more as an illustration of how predetermined agendas and high degrees of formalisation are not seen as necessary or practical in the organisation. Supporting this view, no interviewee expressed a desire for more formalisation. Rather, in the rare instance where formal guidelines were followed, the internal steering group meeting, some issues have been observed.

4.2.2 Internal steering group meetings

The case organisation holds monthly internal steering group meetings (ISGs). There are three main types of actors represented in the meetings: the project organisation, business area organisation and different product lines. The intent of these meetings is to "provide cross-functional leadership and direction in order to maximise project benefits". With the meetings, the organisation mainly hopes to monitor project progress and provide the project managers the help they need in issues that are beyond their scope of control. The ISGs are seen as meetings for solving the issues in projects, and as one interviewee described them:

> *ISG's function is to report project statuses, possible problems. Of course, a good manager has already prepared a plan for the problems. The manager's job is to sell the problem so that he or she gets a sound decision for it. - Senior manager, project operations*

As the quote above says, the project manager has to "sell" the problem to the decision-makers. This means that the manager might have to choose the right way to present the problem, so that she/he gets the best decision for it. As the interviewee also said:

> *It is always also maybe a bit political type of a meeting. - Senior manager, project operations*

However, the interviewee did not want the politics emphasised too much, but acknowledged that these meetings had the aspect in them. Another interviewee felt kind of the same way, but did not explicitly call it a political meeting:

> *When you look at the slideshow template, how many slides are there, tens? It's really hard to get an overview [of a project] from there. It leaves the presenter with quite the power on what things to bring up, since they can go through some slides quickly. Then it's about whether or not someone has paid attention when reading the slides beforehand. - Director, software engineering*

This indicates that the sheer information overload tends to affect the process. The amount of content presented in these meetings are seen as a burden by others, too:

> *In the current template the same thing is presented on multiple slides, maybe it could be simplified. ... It would not need to be but one slide we go through, one view of the project with the most critical information. Then we look at something more if there's something special we want to look at. ... Especially if our project portfolio keeps growing. - Project director*

Indeed, there are separate content items in the ISG presentation template. This high amount of slides, or content, was considered a problem by almost all interviewees familiar with the meeting, and it was felt that they had to fill in the same information in a different form multiple times, making it time consuming and unnecessary. The content of the report is presented in Appendix B, which shows there is quite an amount information to gather. Due to this, time in these meeting is also spent on reading the reports. As one interviewee commented:

> *It's a waste to spend time on going through the reports there. Couldn't everyone do it in advance? - Vice president, solution sales*

However, the same interviewee also found problems with this:

> *Those people who attend ISGs are very busy people, and they haven't had the time to read the reports, and even the reports do not get finished before the meeting, even though they maybe should be ready for example 48 hours before that. - Vice president, solution sales*

As the aim of the ISGs is to monitor project progress, time is spent on all projects, whether they have problems or not. According to the empirical data, this is seen as a bit of a waste, and the actual focus should be more on the issue solving. It was seen as a common problem that projects need to prepare a long report for these meetings, but only a fraction of it is actually used. Also, spending time on projects in good health was seen as a problem: it was perceived that this ate up time from the more important things, i.e. issues that actually need support from the management. These issues tend to require decision-making, and when time is spent on non-critical facts, the decisions were sometimes seen as made in a haste.

To conclude, there are not many formal meetings in the organisation that would involve the lower levels of the organisation, and ISG is one of them. However, maybe even due to the formality, the meeting does not seem to connect with the expectations set to it, and the senior manager level employees feel some improvements would be in place. They felt these meetings should get closer with their true purpose, solving problems in projects, rather than simultaneously serving the purpose of a portfolio review to some extent. However, currently the case organisation seems to be lacking in other portfolio review processes, and ISGs partly fill this gap.

4.2.3 Organisational interfaces

The case organisation has a couple of apparent organisational boundaries, which tend to hinder the information flow through the organisation. For projects, the main organisational boundaries seem to be, according to the interview data, between delivery and development projects, projects and software development, and project operations and sales.

Firstly, let us go through the boundary between delivery and development projects. Earlier, an example given by a project engineer was described, showing that sometimes there are situations where a delivery project is dependent on a development project, but the responsibilities between them are not entirely clear or agreed on. Since development projects follow different processes, schedules, and use different resource pools, it might not always be easy to solve these kinds of obscurities between the two projects. Thus, as delivery projects need follow an often tight schedule, they tend to solve these situations by doing the work themselves, if possible. In a discussion, it was also mentioned that some delivery projects had started doing rudimentary development work by themselves. This was seen as bit problematic, since it could lead to a situation where the same solutions are created separately for each customer.

In the development organisation of a product line it was seen that establishing better communication between the development and delivery project could motivate the employees:

> *We've thought if you could show those projects, mainly delivery projects, that be quite motivating. Like if they designed something in May, what's happening now, when were the machines delivered? - Senior manager, R&D*

Currently, there is no well-established interface between development and delivery projects. However, the needs for this type of "interface management" do not seem well-established either. If the recent evolution of development projects getting more closely integrated with delivery projects continues, better ways to communicate could be required. For now though, better overall awareness and transparency between the two types of projects and sub-organisations could help resolve these issues.

The second relevant interface, between projects and software development, is in some ways similar. Progress status of software development is getting more and more crucial for delivery projects, since products tend to rely more on automation. One reason why establishing communication between the two is difficult, is that software development operates in a different manner than rest of the projects. While software development is done in projects, or as they call them, epics, they follow a different logic. An epic might be related to multiple delivery or development projects, but software development seems to be disconnected from what actually happens in these projects. As interviewees described it:

> *It shows to me that it [software development] is an engineering consultancy where we place orders to. - Project manager, R&D*

> *They've made this organisation a software company … Many of them are quite distanced from our business … In a certain way, they've maybe lost touch of it, so that they only make the software and it works like this … Often they say "yes they worked we've tested it" and then when we go to the site, nothing works and the customer looks with a red face … [When they come work for us,] we should, for instance, take them to actually see the machines up close. - Project engineer*

So, the software development is seen much as separated from the rest, so that the developers are disconnected from the more traditional operations of the organisation. Also, there is a lack of visibility into the software development side:

> *[I would like] more visibility to the software side, progress visibility that is … Of course some progress is visible but it would be nice to see more … What is the situation and what problems are there? How much of the work initially planned has been done? - Project director*

> *There is a gap between the project execution and actual automation design … No one has a comprehensive picture of how big the backlog is, to which we have maybe partly even committed to in the next half or full year. No one really knows if we have committed to triple the amount of work we have the capacity for. - Vice president, solution sales*

As mentioned, the software development organisation has different ways to conduct their projects, as compared to the rest of the organisation. Also, they use different systems for project management, so it is difficult for other projects to understand and access the information in the software development side. As the need for software development has been steadily growing in the recent years, the organisation has not been able to integrate it with the business that it has been traditionally operating in. There are apparent challenges to this, as software business tends to have special ways of working (i.e. specialised methodologies such as Agile development) as compared to more traditional forms of engineering, not only in this company but across industries.

Thirdly, let us go through the boundary between project operations and sales, as also described by Turkulainen et al. (2013). In the case organisation, the main issues with this interface seem to be related to scope, resource, and schedule management. The sales organisation does not have a clear picture of what the operations side can do. This was also a major concern for the vice president of the functional department pooling the resources for delivery projects, as she described in two separate discussions how they have no systematic way of providing the numbers for available resources to the sales organisation. The same issue was also raised by an interviewee from the sales organisation:

> *Have you thought about a perspective of how we could utilise our CRM software pipeline, so that we would forecast our future situation? Because now I see that we've made many automation sales currently, and in addition to that, orders for complex projects have been received, so how could we know and predict in the sales phase if we have the resources to implement those? Because if start recruiting when the sales is closed, we are already late. - Vice president, solution sales*

The issues regarding this interface were also apparent to others, and it was seen that the operations side had to be quite cautious regarding what they can promise the sales organisation:

> *This has always been a challenge for us. In some discussions it is noted that the project delivery organisation is the brake of sales, because we look at things from a too negative perspective. The intent is not to be negative, but to recognise the risks, and if we make risky decisions they have to be acknowledged risks. - Senior manager, project operations*

The same interviewee also elaborated on this point in many different ways, as he was in charge of the production schedules of the machines, and consequently, had great experience in communicating with the sales organisation. With the scheduling aspect, he highlighted the uncertainty and prioritisation of sales projects:

> *Especially in the sales phase, it creates its own challenges in the planning that which projects are coming to us. If at the same time they ask the delivery time of ten projects, and make me believe that the order time for every one of them is next week. Of course then I have to check with the sales that to which project do I promise the shortest delivery time, as I can't promise it to every project, because we sort of have fixed production slots. - Senior manager, project operations*

He also elaborated how the scope promised by the sales organisation can cause headaches in scheduling:

> *If I don't know that this project is going to involve this kind of thing, which we have not ever done before, which has not been completely defined in the sales phase, which product development has not designed, of which sourcing does not have a clue of where the components come from once they're designed as engineering has not been able to define them. So it's really difficult to come up with the delivery time [for this type of product]. - Senior manager, project operations*

Another interviewee also recognised similar problems, where sales does not seem to understand the limitations of the delivery organisation:

> *The sales sells it as same as previous. And when we think about our automation products' lifecycle, the previous can be something that does not exist anymore. In*

> *the beginning, we should spend the time to look at what we sold, and if what we thought we sold is still possible to deliver. … And if it's not [possible], how do we proceed and negotiate with the customer that you're going to get this [instead]. - Director, software engineering*

> *In our organisation we have this saying: "The same as last time, BUT…" – Senior manager, project operations*

Similar issues, or a risk of not considering the limitations of operations, was also recognised in the product development parts of the organisation:

> *The amount [of those projects] should be kept under control. People can handle one or two vague "beast" projects [at a time], but when the amount of them starts to be like five, then that's like, too much. - Senior manager, R&D*

These communicational issues between sales and operational side have not yet resulted in major problems in the organisation. However, better tools for planning and communicating are already needed. And as the amount and complexity of projects increases, as they seem to be doing, risks of not having the needed information available or communicated can grow. Above all, the sales organisation should have a better view on the resources available on the operations side, and the interdependencies between customer and development projects. For now though, it is not a communicational issue only, since the operations side simply lacks the tools to find reliable information on the

Concluding this sub-chapter, in the organisation, three organisational interfaces for projects seem to need special attention. The importance of the interface between development and delivery projects seems to be growing with the current progress of development projects closely integrating to delivery projects. There seems to be a general need for more transparency between these projects and their organisations. As the second interface, projects seem to not have adequate information about the software development in the organisation. This is partly due to significantly differing ways of working, but also, the there is no common tool for sharing the information. Here, it would be crucial for the sales organisation to get information about the capacity and resource availability on the operational side.

4.2.4 Customer communication

The role of customer communication is perceived as especially important in the case organisation. This was often seen as a success factor for projects. Even if projects fail to reach their budget, schedule or scope targets, open communication was deemed as precious:

> *We can succeed even if we fail. … Regarding failing cases, my best memories are from the ones where we have openly communicated the reasons for failure, the*

roots of the failure, have updated the schedule and stuck to the schedule after that. … Honest and proper communication is important to the customer. - Senior manager, project operations

Open communication with the customer is like, the key to success. … The customer is always saying to us "tell me true, tell me early." - Vice president, product line

Quite often, even though the project would go under changes or schedule would be prolonged, and so on, if you can tell it to the customer soon and clearly enough, so if we have that information for us to use soon enough, then we can get into an agreement. But then if it comes as a surprise to the face of the customer, then our negotiation position is bad. - Project manager, R&D

The biggest problem in projects is always the lack of communication [referring to customer communication] - Business controller

So, while the employees seem to value this type of communication, the organisation does not always have the needed information available or communicated within it:

Our ability to forecast production was quite unreliable and came with a latency [at the time]. - Project manager, R&D

If we're late, then of course I want to know it right away if we're late, so that I can react to it in some way, mitigate the implications of it. … The worst thing is when we say it will come on time, and when that does not happen. … If I didn't know [we were late] and had a couple of weeks ago told to the customer [that we're on time]. Then I'll probably lose trust in the face of the customer, which makes life a lot harder in other things. - Project director

Improving communications within the organisation could, thus, improve the ability to communicate to the customer in a timely manner, if the information was better available for project managers. For the customers, the most important thing is that the case organisation can stick to the schedule. Naturally, there is an incentive to do this on the part of the case organisation too, besides achieving customer satisfaction, since contracts have penalties in them. Also, by making any schedule change information reach customers on time can have drastic effects on their business, due to the fact that then they can prepare for those changes and adjust their business accordingly.

4.3 Information systems for project management

4.3.1 A variety of tools for different purposes

The complexity of the projects in the organisation seems to also show in the variety of tools used for project management. Within the projects, naturally, many other tools are

used too, but here the focus is on tools used to manage the project life cycle. The tools used for project management in the case organisation are presented in Table 9.

Table 9. The main tools used for project management in the case organisation

Tool	Use cases
Aha!	Development project road mapping
Excel spreadsheets	Project planning, and management especially for small projects, controllers use for project financials
Google Drive	Project planning and management, communicating project statuses.
Jira	Software engineering project management, resource management
MS Project	Project management, resource management
Sales Force	Sales project management, CRM
SAP	Handling project finances
Thinking portfolio	Development project portfolio management
Trello and other lightweight tools (e.g. Kanban boards)	Managing and bringing transparency to team tasks

As there are such a vast number of different software tools used in the organisation, and these are just the tools used in project management, the employees feel that it is at times difficult to form a big picture of the business, or even a project. As interviewees commented:

> *We have data, we have reports. But what we don't have is a tool easy to use and linked to multiple systems. It's always a separate report from each system. - Director, software engineering*

> *We have Thinking Portfolio, we have Jira, we have MS Project, but not a comprehensive one [system], so the understanding about the situation is formed through each of them. - Senior manager, R&D*

Another view to this problem was that there should be one dominant system:

> *We need some added value [from the system], either through reporting or some other way. That way we can push people to use one system systematically. - Project manager, R&D*

However, it seems that any one project management software would not suit all the needs in the case organisation:

> *[The new PMIS] is, for now, quite useless for us. Our customer planning, for example, is way too short-spanned to be guided like that. It is pretty much brought*

> *to our environment to suit the megaprojects' needs, so our customer planning projects, if we for example sell two machines somewhere, …, then it's like 800 hours, and then it further divides to different areas of expertise, so it's a really heavy way. - Senior manager, R&D*

More complex projects need more comprehensive tools, and if smaller projects are forced into the same tools, their processes complicate for seemingly unnecessary reasons, at least from the perspective of project managers. The organisation is still in the progress of fully deploying a new PMIS into use, and it is not yet comprehensively adopted by the most complex projects, though the system is most suitable for them. Thus, it pushing this one system for all projects could probably result in quite the dissatisfaction among the employees. In the next sub-chapter, the new system will be discussed deeper.

4.3.2 New project management information system

The case organisation has somewhat recently taken a new PMIS into use. Originally the tool was intended to support largest projects of the case organisation in project management, and to enable scheduling and booking of resources to project. The resource management in the organisation now relies on this tool; generic resource requests are delivered to resource owners through the system, who book named resources to the project in the system. Not all projects see the tool worthwhile as a planning tool, but most projects have to use it for the purposes of resource management. Software development, though, uses a different system for this, too.

The planning of the new system started in Q1 2015 and the rollout of the system began in Q1 2016. Now, over two and a half years after the rollout, an interviewee that had witnessed the implementation project close up commented:

> *We ran out of juice [on the implementation]. We're still wrapping it up. - Director, software engineering*

However, as all of the project resource management (except for software engineering) and much of the project management was being done through the system, the organisation recognised an opportunity to use the data in the system in a more comprehensive manner. Thus, one reason why this research is being done, is to support the further implementation and use of the PMIS, and to recognise uses for the data. For now, projects and their data are being logged into the system, but that data is used in a structured manner. This seems to show in the data quality, as no one really cares about it, and to be fair, there is no reason to: the data is not being used, except for resource management.

This being said, to enable useful reporting practices using the data in the system, the data quality would have to be improved. The manager responsible of project performance improvement in the case organisation saw that the best way to do this would be to start building the reports. His rationale was that, to improve data quality

- the data has to be visible,
- there have to be ways to utilise the data, and
- there has to be upper management commitment to improve the data quality.

The first two points would realise quite automatically if reports were produced from the data. He also saw that it would be crucial, at an early stage, to build reports that would prove useful to the upper management. Having reports with real value for upper management would then make them more committed, and data quality could be made a priority in the organisation. An interviewee also had the same idea, but focusing employees using the new PMIS, rather than addressing data quality directly:

> *If we just had an obligation coming from the management that you must use that [system], you got to have a stick or a carrot for that, now we really don't have either. - Project manager, R&D*

Currently, most projects use the system, but not quite in the intensity and ways wished by those still trying to improve the system. The only aspect that seems to be used rigorously enough is resource management, and this is simply because the customers are often billed using the hours data logged onto a project in the system. Unfortunately, almost any other data seems to have major problems, rendering it unusable for now. Thus, using business intelligence is seen as a tool to improve the data quality, and only after then, BI could be used for actual business purposes in this domain.

4.4 Multi-project management and project portfolio management

4.4.1 Need for structured portfolio management processes and tools

In the case organisation, multi-project management and PPM rely quite heavily on internal steering group meetings (ISGs). Within the management, there can be other, often ad-hoc, decision-making processes to support these functions, but the ISGs are a regular way to manage the company projects from a higher perspective. However, as the project management maturity seems to be progressing in the company, the need for more has been noted. Right now, the development projects have a fitting tool to support the PPM process, but customer projects lack in this regard. Thus, a need for managing the customer projects from a holistic perspective has arisen, and consequently the need for new tools.

Among senior management, PPM had also been voted clearly the most important issue to solve in the organisation, including sub-issues such as lack of prioritisation and communication about the portfolios.

Right now, it is hard to get the needed information on customer projects, as the data is scattered across systems: ERP systems hold budgeting data, and PMIS holds data some, but not all, data on most projects. And even though development projects have an established portfolio review tools and processes, as noted before, the customer projects are also often dependent on the development projects. As the development project use a separate tool for PPM, the data is difficult to integrate with customer projects. With the vast number of on-going projects, gathering and comparing this data manually would take too much effort. And even if it was possible, there is no guarantee that the data would be up-to-date in all systems, and checking that would even further escalate the effort needed.

> *Yes, you could improve the portfolio management process, so that the management would have a view of the whole portfolio and could go through certain projects. - Project director*

Why has the need to manage the customer projects from a higher level occurred just now? Well, firstly, the ISGs have served that purpose, at least to some extent. But there, projects are presented one by one, making it difficult for managers to see the big picture. Also, since these meetings are directed towards solving problems, focus on the portfolio level is missing. For example, if the meeting chooses to allocate more resources to help one project, the consequences of that decision can be hard to take into account, and might not even be considered, since the objective was to help that particular project.

As there is now an established need for better PPM, the employees also acknowledge the problems with current procedures. As the ISGs contain too many details, there is a call for simplicity. When I showed an interviewee an example of what kind of reports could be built with BI tools, he commented later on:

> *The traffic light report you showed was good, that is what we need to show to upper levels. No detail-level report is wanted, you have to get the information on a quick glance. - Project manager, R&D*

The need for PPM tools had also been set as a top priority in the meetings the researcher had attended. However, these tools could potentially also support a larger audience, than just those responsible for PPM. As recognised earlier, for example regarding the relationship between development and delivery projects, there is a desire for general transparency within the organisation. If the tools for PPM were developed with BI, the same data and platform could be reused to provide information about projects elsewhere in the organisation.

4.4.2 Project interactions and prioritisation

As already mentioned, one issue the organisation is facing is that no one has clear picture of how changes to projects affect the other projects or activities. This is further amplified by the fact that most development activities (i.e. software development) do not use the same project management tools as customer projects, making it even harder to grasp the effects of changes made. An interviewee described the problem and possible solutions to it in the following manner:

> *A systems integration, where data of different systems would be in the same place, would be key, so that you could see that "okay, there's the milestone, where do we need it, here's the epic now, what will happen if we move it so that we can do the other epic first? ... To make so much as decent prioritisation decisions, we should understand, what will happen, if we do something. - Director, software engineering*

An interviewee explained how projects are prioritised in the organisation. He saw the overall customer profitability potential as the most important prioritisation factor. As he put it:

> *For certain customers, the projects are followed up in a wholly different way. ... We [our team] knows who will suffer if a project of Customer X [name changed] has to be hurried. - Vice president, product line*

When taking this prioritisation view and the views expressed in previous parts by the interviewees about the importance of customer satisfaction and communication in the organisation, it can be concluded that customers are especially highly valued in the organisation. The organisation prioritises projects from the by customer lifetime value, delivers reference projects to ensure future orders, and projects attempt to keep the customers satisfied with timely communication and aligning project objectives with the expectations of customers. Due to the high valuation and prioritisation of customers, it seems that the customer viewpoint is something to be paid close attention to in measuring and monitoring the business, too. Right now, this viewpoint into prioritisation does not seem to be quantified, but rather it lives in the cognition of the employees.

Currently, in the organisation, development projects enjoy the benefit of a single PPM tool, which helps the management make their prioritisation decisions. But when it comes to customer projects, or customer project related development, the decisions are usually more restricted, as they cannot realistically be cancelled. Thus, it is usually a question about which project gets to use the resources first, whether that is hardware production, software development, shipment, engineering staff, or any other resource with limited capacity in the organisation. Because of this, I am here connecting project interactions with prioritisation, as prioritisation decisions are in this context dependent on interaction with a certain resource or a resource pool.

As one of the initial goals, set by the organisation, was to improve the decision-making transparency in the organisation, it is essential that even these "softer" prioritisation variables, such as customer priority, would be made transparent, too.

However, as mentioned by an interviewee, efficient prioritisation decisions would require the information on what will happen when a certain decision is made. As prioritisation decisions, for example in terms of resource use, can affect both the resources or their pools, and the projects, it would be beneficial to see the status of the different influence Thus, it would be beneficial to also see all of the aspects that would affected by the decision as effortlessly as possible. If the required information is stored in multiple systems and cannot be easily accessed by all decision-makers, the transparency of the decision can suffer.

For the case organisation, though, there are such a vast number of different resources which prioritisation decisions can affect, that bringing them all into one system might not be realistic, at least for now. Some information that is produced outside of the case organisation, could be hard to integrate with the organisational systems. An example of this could be the production schedules of an external manufacturing unit. Then again, other information, such as data on the schedules of the internal software development, could probably be available for use, if there was enough desire to pursue it.

For now though, as the main data source considered in this study, in regards to the case organisation, is the data available from the PMIS, the first step could be to bring this information available more broadly into the organisation. Even though all resource data would not be integrated into the system, it could still be beneficial for the resource managers to be aware of the situation from the project data that is readily usable. For example, if a project needs to be completed earlier for some reason, it could be useful for all the resource pools to know this, even before any schedules are changed. Da Silva et al. (2017) examined a solution to this type of a problem as a part of their study. They had an interactive tool that would show the effects of schedule changes to a portfolio (e.g. portfolio feasibility). While the same types of interactive tools are not exactly in the scope of this thesis, BI could solve these issues to some extent.

4.4.3 Resource management

In the case organisation, line managers are responsible for nominating resources, including task and Work Breakdown Structure (WBS) owners, for projects. Thus, it is their job to ensure that planned resources are available for the project and inform the project management of any issues regarding resource allocation related to their project. If an issue cannot be resolved between the project manager and resource owner, the issue is solved in ISG.

It seems quite unanimous among the interviewees that the organisation would need to better its resource management processes. A discussion with a vice president of project services led to a conclusion where it was described that the organisation currently cannot provide the sales department exact numbers regarding resource availability. Thus, for example, the sales organisation can be offering projects for which there just are not enough engineering hours available, and the vice president has stop them. Still, no exact information about the future resource use cannot be presented to the sales department, as it is not available. The information seems to just be more based on conceptions and possible occasional ad-hoc analyses.

An interviewee described the problem with inadequate information in the following way:

> *Especially the software resources, we don't have adequate long range planning. We should see when we commit to something if we really have enough resources to do it. - Vice president, solution sales*

> *When a sale has been closed, we're already late if we start to recruit the resources at that point. We can't get skilled people in such a short timespan that it would actually help. Somehow we should be able to forecast better what's going to be on our table in the future. And not only scoping it to the Case Organisation, but for example our joint venture company is a very important party in our operations. - Vice president, solution sales*

But also, even if there was a good availability on the information, other things can go wrong, as a project engineer described in an interview:

> *Project managers cannot accurately say what should be done and when and for example they book 100 % of your hours for three months. Then you're booked at that time and others ask for resources, but I'm booked. And in the end, not even half the work is realised. … More accurate scheduling and such, that should be better in this firm. - Project engineer*

When one interviewee was asked if the current information systems supported his work adequately, he responded:

> *Well, no. The resource management, that I still have to do [manually] with spreadsheets. - Director, software engineering*

Thus, successful resource management is dependent on tools, and correct estimation of tasks and the resulting resource bookings made. Currently, there is no structured way to check how correct the estimations are, and the empirical data did not reveal this to be a large problem. With suitable tools though, the organisation would be able to see how well its resource planning actually works.

While not a direct key performance indicator, but a factor in operating profits and overhead costs, resource utilisation is used to track departments in the company. In the same way as Engwall & Jerbrant (2003) noted, the departments get compensated for time spent on projects, while overhead activities are considered as costs. One of the first needs expressed in the organisation, related to this research project, was that resource managers should be able to better access this information. Also, a senior manager in R&D had already independently started developing a suitable BI tool for monitoring resource utilisation, so clearly there is a need for development in this area. The indicator, though, was also seen as a problematic by itself:

> *If everyone logs 100 % [utilisation], then that's a really good thing for the cost centre, but from the eyes of the results, it can be a bad thing, because if we have a budgeted amount of projects [80 % utilisation in this example], then we've worked too much, or we've worked more slowly or worse in that sense that we've done more work than planned. … But when the utilisation rate exceeds the budgeted, then that's a good thing when we have more projects [than budgeted]. - Senior manager, project operations*

The same was noted by Engwall & Jerbrant (2003), too, but in the sense that there were little incentives for productivity improvements. Thus, this kind of measuring can, indeed, lead into problems by itself, if people and departments start to "optimise" their performance through the utilisation rate. This being said, providing better mechanisms for keeping track of this indicator could also make the organisation direct its resources into more non-sustainable work.

An interviewee also saw the suitable amount of simultaneous projects as a factor for project success:

> *The project team has to be such that the people, for real, have the chance to work on it [the project], meaning that they should not have too many other things on their plate. I'd say two or three is a maximum [of projects]. - Senior manager, R&D*

However, he did not consider the fragmentation of work, or project overload as described by Karrbom Gustavsson (2016), a particular risk, at least yet. This does not seem like a significant issue in the organisation, but right now, it is also difficult to systematically track how many projects each employee works on at a time. As teams in the organisation tend to hold meetings to discuss daily and personal issues, each employee of course has the chance to let their supervisors know if they are overloaded with projects. The interviewed business controller, however, explained that controllers are currently at the risk of having to jumble between too many projects. Thus, it seems that the issue is not yet wide spread, but can be more prominent in certain roles.

4.5 Summary of project management characteristics and issues in the case organisation

Project management in the case organisation is characterised by well-structured methodologies and guidelines, while not sacrificing flexibility. The flexibility shows particularly in being able to successfully conduct various types of projects in parallel: delivery and R&D, small and large, routine and complex, to mention some contrasts. Projects have high autonomy, while not compromising on the standardisation. Project finances are also under tight control. However, this seems not to burden the organisation excessively, but rather ensures that changes and anomalies in projects go well documented.

On the other hand, the issues the organisation is facing focus on the tools and technologies used in project management. While the methodologies and guidelines are useful, following them has become more difficult as the complexity of the project environment has increased. Thus, the level of the tools used in the organisation does not quite match the maturity of the overall project management.

As this study focuses the project management tools and technologies, these issues gain emphasis, instead of the positives. This, however, should not give the impression that the organisation is failing in project management, as the reality is quite the opposite. Especially for the interview data, the data collection was also more aimed at fulfilling the gaps in project reporting, rather than focusing on the positives. For interviewees, it also seemed easier to focus on matters that were not going so smoothly in the organisation. For the purposes of this study, however, fixating on the issues the organisation is facing is not a problem. Finding the issues, especially regarding project management tools, is rather proof that improvements on reports and BI have their place in the organisation. From the data, five main issues regarding multi-project management in the case organisation have surfaced, and these are presented in Table 10.

Table 10. Main issues in multi-project management in the case organisation

Issue	Further explanation
Lack of PPM tools and methods	• Especially an issue for delivery projects • Also, internal steering group meetings are seen as out of focus, which might be partly because it serves the vacuum in PPM
Lack of resource management tools	• Anticipating future demand is especially difficult
Lack of information availability from projects and from organisational units	• High levels of collaboration and dependencies require information to be available • E.g. sales would need to know resource availability in operations • Development projects and software development units also in constant collaboration with delivery projects
Many tools for project management and lack of integration between them	• Currently, no tool can provide the full picture: employees need to use multiple systems concurrently
Low quality of project management data and lack of incentives to improve it	• Data is not systematically used, and thus there has been no incentive to improve the quality of it • Sufficient data quality is a prerequisite for the use of the information

Many of the issues presented in the table can be seen as connected to each other. For example, the low quality of data is something that could, in this BI context, affect the mentioned PPM tools, resource management tools and information availability from projects. These tools would not work as intended, if the data quality was not at a sufficient level, and information availability from projects would not make a great difference if the information was not reliable, for instance.

The lack of PPM tools and resource management tools are issues that were mainly expressed by the senior management level employees. These issues were also the most apparent from the start, as they involve concrete tools, and due to the lack of them the managers are forced to do more manual work. This, of course, causes some frustration, which made the managers eager to express their concerns on these issues. As it has been established earlier, PPM and resource management are also considered integral parts of a multi-project environment, and thus it should be no great surprise that tools for these activities are needed also in the case organisation.

The lack of information availability seems like a general concern in the case organisation. A multitude of factors could have a role in it, including organisational boundaries, lack of common information systems and the vast amount of information causing information overflow. As the case organisation is characterised with a high level of dependencies between projects, organisational units and other collaborators, information is often needed from and by actors outside of a certain project. The lack of transparency in decision-making was acknowledged as an issue in the organisation right from the start, but with

the data, I have come to the conclusion that the organisation lacks in information availability in general.

The issue of many tools for project management and lack of integration between them also relates closely to the abovementioned aspect of information availability. As there is no common and familiar platform to reach all relevant information from, employees find it hard to find the information they need, and thus it can seem unavailable to them. In the case organisation, for instance, it might be difficult for a project manager to check the production status of a software component related to their project, as that information is in a different system than the main project. The project manager might not be able to access the system, understand the system or the system can have insufficient information about the issue, so in other words, the quality of the data is too low.

The last main issue, low quality of project management data, was not an issue directly available from the interview data. Rather, it is an issue tightly connected to the goals and results of this thesis, and thus is not an immediate concern of most employees. The issue was noticed when the data in the main PMIS of the case organisation was inspected. The data showed that its quality was consistent with how, and whether or not, the data was used. For example, the data on resource use was quite good quality, which was expected as that data was already being used for billing purposes. However, while we are still discussing a PMIS, the quality of the actual project management data, such as scheduling and project milestones, were not something to compliment,

There are also other project management characteristics and smaller issues present in the organisation. These are presented in Table 11.

Table 11. Other project management characteristics in the case organisation

Category	Characteristics
Project management	• High variance in project environments: geography, customers • High levels of collaboration and project dependencies • Customer satisfaction as a success factor
Multi-project management	• Importance of customer profile in prioritisation • Importance of revenue recognition and forecasting it
Communication	• Meetings as an important communication mechanism - few other mechanisms to integrate information • Importance of timely customer communication
Project management information systems	• New PMIS adoption still in progress • Projects vary between each other - one system does not fit all needs

Each of the characteristics presented in the figure will not be addressed in such a detail here, as they have been already discussed in previous sections. However, something to

note here is the customer perspective: the case organisation tends to highly value its customers, both in terms of satisfaction and communication, and prioritise projects according to their profile. However, as the customers are also highly heterogeneous and have different needs for example in terms of communication, the customer aspect is not a main issue to address in this thesis. This variance in customers and in project environments in general, seems to rather call for flexibility in terms of any tools presented here.

The high levels of collaboration and project dependencies could both be supported with tools in PPM and resource management. For example, a proper PPM tool could show the dependencies between projects and a resource management tool could bring information about the availability of resources at a resource pool a project is dependent on. As for the project dependencies, the case organisation has already noted the issue also in another context, and is trying to find ways to avoid possible problems caused by these dependencies. Also, the importance of revenue recognition, and forecasting it, is something that could be supported with suitable tools for PPM, and thus it is not raised as a major issue.

It should be noted that the characteristics and issues presented in this chapter do not objectively represent the nature of project management in the case organisation, as they have been collected with a specific aim to support the organisation with BI tools. Thus, they are, for the most part, related to some kind of communicational or information sharing aspects of project management.

While the issues and characteristics have been collected from a BI and reporting perspective, it is important to acknowledge that these tools are not a panacea. And even if it was possible to influence most of the issues with these tools, the success of such a complex multi-project environment depends on a multitude of factors, which may or may not be influenced with the tools discussed in this study.

5. FORTHCOMING SOLUTION DEVELOPMENT

5.1 Organisational views on business intelligence development

Many of the interviewees had a keen interest in developing this kind of a BI solution for better project management. Due to the interest, the interviewees had some views on how such a system should be implemented and what kind of a system it should be. So, some of them could directly point out concerns regarding the development of the BI solutions, based on their past experiences in the case organisation. For example, considerations about the adoption and prioritisation in development were expressed. In Table 12, the main considerations and ways to address them.

Table 12. Considerations regarding BI development in the organisation and ways to address them

Consideration	Reasons / explanation	How to address
Complex systems	Systems are too complex and require too much expertise from users	• Focusing on simplicity • Providing ready-for-use tools
Wide scope	Attempting to serve too many users and use cases, and not enough resources to fulfil all needs	• Defining key end users • Defining key use cases • Prioritisation
Unfinished business	Development slows down toward the end, without ever fully finishing	• Defining scope clearly • Formally finishing the development
Know-how transfer	Development relies too much on individuals and know-how is not transferred (especially important in terms of staff turnover)	• Involving a team in the work, not only individuals • Creating documentation
Neglecting further development	Forgetting to review user experiences and user needs after implementation, and neglecting the development based on those	• Gather user needs and feedback continuously • Plan reviews for further development

Complex systems, the first concern in the table, had been witnessed in the development of similar BI solutions in the organisation. In this case, the solution, however, focused solely on presenting financial information mainly for the needs of business controllers. An interviewee described the solution as follows:

> *[It] has not been thought from the point of view of the user, so that it would provide you the report you want to use as default … You have to remember an awful lot of selections and if even one of them is wrong, the data is wrong … Less is more. - Director, software engineering*

Here, the interviewee saw the solution as not user-friendly because of its complexity. He did not consider the system particularly a success. The interviewee saw these complex systems as a result of the second concern presented, wide scope. To avoid this issue, the interviewee gave the following advice:

> *A couple of end user cases have to be defined. For what the tools are actually used and make sure that when you open the report, that it is actually valid for that use case. And after that, if you want to go deeper, then it's fine that you actually need to know something. … We should not imagine that we have a basic view from which the users keep clicking themselves to the target. - Director, software engineering*

Essentially, what was meant to be emphasised with this was prioritisation. Considering the available resources and the size and complexity of the case organisation, prioritisation was seen as essential.

The next concern, unfinished business, was witnessed with the implementation of the current PMIS. The main parts of that implementation were completed well, but after the system was up and running, the finishing and supporting activities were seen as lacking. As the same interviewee described:

> *It would require more training and establishing the common rules. - Director, software engineering*

The next concern, know-how transfer, is related to the previous concern in the PMIS example. A reason for why implementing the PMIS feels unfinished to people might be the fact that the employee left the organisation soon after. The advice given by the resource management solution owner was that proper documentation should be created to support transferring the know-how, especially in the case of employee turnover. As an interviewee described the situation:

> *There's the danger, which has been seen before, that someone has made something and then they have left the company or something. Okay, they did that but we don't know how to use this. … I think, when the person who was responsible for the project management system, when they left the company, we were left here flabbergasted. - Project engineer*

Lastly, it was felt that the organisation tends to neglect further development of these types of solutions. An interviewee saw that when any solutions are considered ready, there should still be resources available for the future development. The rationale for this was

that it takes some time for the users to adopt the tools into their work, and after that only will the daily problem areas show themselves. Thus, it would be important to gather and review user needs and feedback continuously even after the implementation, and make sure the system can still be developed further.

5.2 Limitations for business intelligence development in the case organisation

The limitations for BI development in the context of the case organisation and its project business are presented in Table 13. The limitations are further discussed below.

Table 13. Limitations for BI development in the case organisation

Limitation	Explanation
Data sources difficult to connect	• Large organisational systems are protected and difficult to access • Resources for technical assistance difficult to reach
Proving a concept	• Resources for development are quite limited • No full organisational support before proven
Data quality	• PMIS adoption not complete • The same PMIS is not used by all projects

The first limitation in the table, about data sources being difficult to connect into the BI solution, is both a technical and an organisational issue. As the control and expertise on the data sources, or IT systems, is dispersed within the large parent organisation, it is difficult to reach people who have the technical expertise and the incentive to assist in connecting the data. Also, especially large, parent organisation-wide, IT systems are governed so strictly that gaining access to them can require broad organisational support. An example of this type is the ERP system of the organisation, which contains the most of the financial data for the projects. While gaining that organisational support might not be easy, what makes it even more difficult is that there are similar and approved BI solutions already in use in the company, and focusing on one is a matter of principle. The main PMIS, however, is controlled and accessible by the case organisation. This limitation means that, for now, the reports to be developed would rely mainly on the data of the main PMIS, and any other data sources under the direct control of the case organisation.

The second limitation, proving a concept, is also related to gaining the organisational support discussed in the previous paragraph. The development of these reports could be considered a small-scale pursuit in the organisation; it is not marketed loudly, vast amounts of resources are not being invested in it, and it is not expected to change the way

of working in a blink of an eye. This also means it still lacks the organisational support, which is intended to be built by proving the concept. The result of this limitation here is that the development will, for now, focus on a small set of the most critical reports aiming to prove the viability of using BI in this environment.

The third limitation, data quality, has already been discussed in the previous sections, mainly from the point-of-view of how to overcome the issue. Combined to the previous limitation of proving a concept, this limitation means that the focus of the BI development will be on reports that are worth pursuing from the data quality point-of-view. Because the data quality is a prime issue for the organisation and BI development, ways to improve and monitor data quality will be pursued within the reports to be presented in this study. For instance, this can mean sacrificing some other qualities of the reports in the pursuit for better data. Current data models can also prevent programmatically addressing some organisational issues, such as project interdependencies. The organisation is also lacking the management of historical PMIS data, and as some data fields in the PMIS are overwritten when updated, the history cannot be fully utilised.

Based on the limitations and organisational needs, the priorities of BI development in the organisation have been placed on two categories of reports: portfolio management and resource management. Firstly, focusing on portfolio management can address the organisational issues in a wide enough manner, as it builds on single-project information and can provide tools to the significant pain points the organisation has in terms of PPM. Resource management, on the other hand, is something the currently available data sources support best, as the main PMIS is used for that purpose. At this stage, the usability of data, and consequently the usability of the related reports, acts as a prioritisation factor. There is also a clear call for better resource management tools, which might be emphasised due to the high representation of senior managers in the data collected.

5.3 Requirements for business intelligence solutions

5.3.1 Portfolio management

The aim to improve PPM in the case organisation using BI was explicitly stated from the very beginning of this research. The aim, however, was not something that received special attention in the interviews. This was probably due to the fact that most of the interviewees tended to manage and control resources instead of portfolios. Still, the problem in lacking the appropriate PPM tools was acknowledged widely, but the interviewees just did not have that much of a personal stake in this pursuit. The internal steering group meetings, though, were something many interviewees saw as improvable, whether the solution was BI or not.

The need for BI in PPM was mainly driven by the manager responsible for project performance improvement in the case organisation. As PPM, from different viewpoints, was

a significant part of his work, he already had quite clear opinions on the BI report when this work was started. According to his initial view, which was cemented in meetings with other employees, the report should give a view on a state of a portfolio with a quick glance and have an option to look at more details regarding individual projects, if needed. Roughly a third of the meetings reported in the research diary were arranged to discuss how this type of PPM reporting should be arranged and what information should and could be presented in it. Thus, the report was perceived as crucial to the organisation. Another factor in why so many of the meetings focused on PPM reporting, might be that it was also perceived as challenging. As this report was seen to be providing an overall, and a multifaceted, view to the portfolio, it was not entirely clear which information should be presented in it. Also, since a variety of information from different sources could be presented, the technical capabilities and limitations regarding the utilisation of this were not always clear. Due to these technical aspects, a lot of discussion and investigation was needed.

In discussions, it became clear that these types of reports would be most useful at the upper management levels, while, depending on the position, the senior manager level could find it useful, too. However, since developing these reports would not be an organisation-wide pursuit, but rather a proof-of-concept seeking to explore the possibilities of BI in these circumstances, it was acknowledged that it would be very unlikely to have upper management take the reports into use anytime soon. One reason for this was the issues with data quality: the reports would not be usable until significant improvements were made.

As project management in the organisation is strongly rooted in the traditional “iron triangle” way of measuring project success, establishing the information needs for this report type started from schedule, budget and scope. While the data on schedule and finances was quantified and most likely quite effortlessly available, measuring scope in an automated manner seemed difficult. Investigating the traditional reports (i.e. reports for internal steering group meetings) being used in the organisation, it was noted that this information was based mostly on descriptions made by the project managers, and sometimes it was easily quantifiable into the number of machines to be delivered to the customer. However, even when the scope had been quantified, the actual evaluation was not unambiguous, since every different machine would affect the actualisation of the scope in different ways. In addition to this, while the machines could be quantified, quantifying the software scope seemed even more difficult. Following the above presented arguments, it was decided that automatisation of scope measuring would not be pursued for now.

For schedule metrics, our meetings lead to a conclusion that two different views should be implemented, based on the project milestones used in the organisation for delivery projects. The two milestone types were critical milestones and handover milestones, and while all milestones could have been treated as the same, the handover milestones being

included separately emphasises the importance of handovers to the organisation, as described in previous sections. These two milestones were already used in the PMIS, so comparisons between them and project schedule baselines would be simple to make, while data quality could still be the restricting factor in the utilisation of these metrics.

For cost metrics, the initial idea presented in discussions was comparing the project original cost plan to the latest cost plan, partly because these two figures were quite easily available for use. Especially for large projects, extending the scope along the way is common, so this comparison might not be useful for all projects as both costs and expected income can increase. Still, other ways to analyse costs were not analysed too deeply, because most of the financial data exists only in the ERP system of the company, and being able to access and utilise that data seemed quite uncertain.

Other metrics presented in the discussions were risks and customer satisfaction. In the risk metric, the estimated cost impact of project risks would be compared to the risk reserve available to the project. In the customer satisfaction metric, a simple monthly average of customer satisfaction surveys for a project would be used to determine the state of the project in that regard. However, for neither of these metrics, the systems for collecting the data were not fully available at the time, so they could not be immediately used.

Instead of showing information separately for each project in a portfolio, the information could also be aggregated, for example to show "totals" for the portfolio. However, as that information would build on single project data, and the data quality creates limitations to its use, aggregated data would be difficult to trust. A specific way to represent a project portfolio was presented by Killen (2013), where project interdependencies are shown visually. The case organisation could also benefit from this type of a presentation, but currently, the technical limitations make it not worth pursuing.

5.3.2 Resource management

The importance of finding BI solutions for better resource management was emphasised especially by the senior management level. While information about resource use often needs to be reported to the upper levels of the organisation by the senior managers, the senior managers first needed easier ways to gather and digest this information themselves. Two distinct needs stood out from the data in regard resource management: project utilisation and comparing resource demand to capacity.

The first need to be explicitly stated was measuring the project utilisation of resources. By project utilisation, I refer to the percentage a resource (i.e. an employee) spends on a project that is billable from a customer. The interest in this figure was based on the incentive system used in the case organisation, where these billable project hours count as profitable while other activities are regarded as costs. As so, senior managers need to report these incomes and costs to upper levels, and cost centres would have to reach their

utilisation targets to appear as successful. However, the mentioned utilisation figure, by itself, does not do much. That figure would be available to the managers anyway, since after all, the organisation monitors it.

Instead, to be able to affect the factors behind the figure, details about the activities would be needed. Some managers had previously manually put together these kind of reports for the upper management, and so chance to use BI to automatise this activity was recognised. For example, in a discussion, one senior manager told he had put together a graph that would show how much of monthly working hours at a department would go to engineering, management, meetings, support for other departments, system downtime etc. The same kind of information was hoped to be presentable, while automating the process, with BI. On the other hand, some managers just needed to see the utilisation rates of their resource pools divided into weekly segments. The difference here might be that those managing a larger pool of resources, might need a more overall picture, while those managing a pool of say, maximum of ten members, have no need to categorise and present the utilisation any further. For both types of uses, the ability to see the utilisation filtered by resource group (e.g. software engineer, mechanical engineer, R&D) was also seen as important, since these groups might use their work hours differently.

The second distinct interest in terms of BI focused on resource demand versus capacity, especially in terms of forecasting the demand. Currently, the organisation lacks ways to efficiently gain an insight into how future projects are going to load the resources. What the managers can see though, is whether a certain resource is still available for booking for a certain timeframe, but it is difficult to get an overall view of the resource availability. This future demand for resources can be roughly divided into two categories: planned demand and non-planned demand, referring to the state of the project. Essentially, the projects not yet planned are still in their sales phase, which causes significant uncertainties onto whether or not the demand is going to actualise. The importance of gaining insight into the future demand concerns especially sales management and resource acquirement. Firstly, sales management would need to know if a project can be carried out after it has been sold, this requires an adequate amount of resources to be available. Secondly, if the organisation makes the choice of selling projects that it cannot carry out with the current amount of resources, the organisation needs to acquire more resource. Depending on the job and needs, this can mean either sub-contracting or hiring new employees.

In addition to planning the future, showing the information on resource demand (or use) compared to capacity could also show if resources are available at the given moment and which activities are using them. Now, this type of resource allocation is done, for instance, in a spreadsheet by categorising employees into competence groups and checking availability. The main PMIS also offers ways to do this. Reallocating resources between ongoing projects is also a matter of prioritisation, which then is more of a PPM activity.

5.3.3 Information availability in general

In the organisation, information availability is restricted by the rather common departmental differences (e.g. Dougherty 1992). This can, for instance, show as difficulty to perceive who holds the needed information in another department. Since projects constantly need to combine information from different organisational units, and those organisational units need information from projects, the general availability of information is crucial. As project managers act as the main point of communication between projects and outside actors, managing these communication channels can take a lot of effort.

The projects themselves, however, have their own mechanisms of sharing information. But when projects are interconnected, one project might have a difficult time gathering information about another project or activities the former project is dependent on. For example, if a project has both hardware and software components, and the software development is organised in a separate project (or epic), problems may occur. And this is often the situation in the case organisation, since any major software development endeavours are arranged through a separate organisational unit, as their own, smaller projects.

In the case organisation, where interdependent projects are often organised through different departments, the information availability could be hindered by both the organisational structures and possible use of different information systems. This is the situation between delivery projects and software development in the case organisation, and these software components are as integral parts of the delivery projects as any, but without a common information system the needed information can be difficult to retrieve. The sales organisation and project operations organisation have similar issues, but without the aspect of individual projects. To plan and forecast future business, and foremost the use of resources, the information flow between these departments should be enabled. Better yet, the information could be integrated in one information system.

With these issues presented, BI could provide a common pathway between the organisational units, whether it would integrate all information or provide better views to some organisational information. While the organisational structures cannot be changed using BI, at least a common information system could be established between organisational units and project business. Currently, there are many technical issues to overcome in this domain (e.g. connecting data sources, modelling project interdependencies to data model). Still, improvements in information availability in the organisation are needed, and BI offers a way, albeit the technical issues might lower the priority.

5.3.4 Data quality

Currently, the state of the data quality is a crucial inhibiting factor in the use of project management data. Even if the data could be checked from the PMISs, employees cannot really trust it to be up to date or correct.

However, even while this problem has been acknowledged, there is a lack of means to address it. The data is not being aggregated systematically, so with a large amount of ongoing projects, monitoring the data could mean checking this large amount of projects and their data individually.

The BI solutions are proposed to help this problem via aggregation of the data. This way, for example, any project missing the needed data (e.g. proper scheduling) could be highlighted in the BI reports. This would give the managers a tool to find out which projects are not filling their responsibilities in terms of data quality, and improvement of the quality could then be enforced. Without improving the data quality, it is difficult to see how any BI solutions could be successful in the organisation. As the PMIS is used as the main source of data, managing the data quality could also be seen as an activity that supports the use of the PMIS.

More systematic manners of controlling data quality, instead of relying on BI, could also be used. For managing data quality, there would probably be better tools, since it is not a core feature of the tools explored here. However, as this BI development more of a proof-of-concept type of an endeavour in the organisation, additional resources needed for specifically focusing on data quality might not be available before the use of BI is proved useful. Additionally, monitoring data quality systematically is a more technical subject matter outside the scope of this thesis.

5.3.5 General report priorities

Through the analyses presented above, some general priorities important to the case organisation regarding the reports were found. These are presented below.

Report priorities:

- *Simplicity*
    - Top-levels of the reports should provide information at a quick glance – avoid figures, prefer visual cues
    - Utilise drillthroughs in presenting more detailed information
- *Ease of use*
    - Define key users and make default views usable for them with minimal configuration
    - Minimal expertise needed to use the reports

- *Highlighting data quality*
    - Make users aware of what kind of data (quality, timeliness, etc.) they are basing decisions on
    - Provide tools to enforce better data quality

The reports introduced in the following part attempt to follow the report priorities presented above. As examples of the reports will be provided, elements in those examples will be analysed from these perspectives.

5.4 Solution proposal

An overview of the solution proposal is presented in Figure 10.

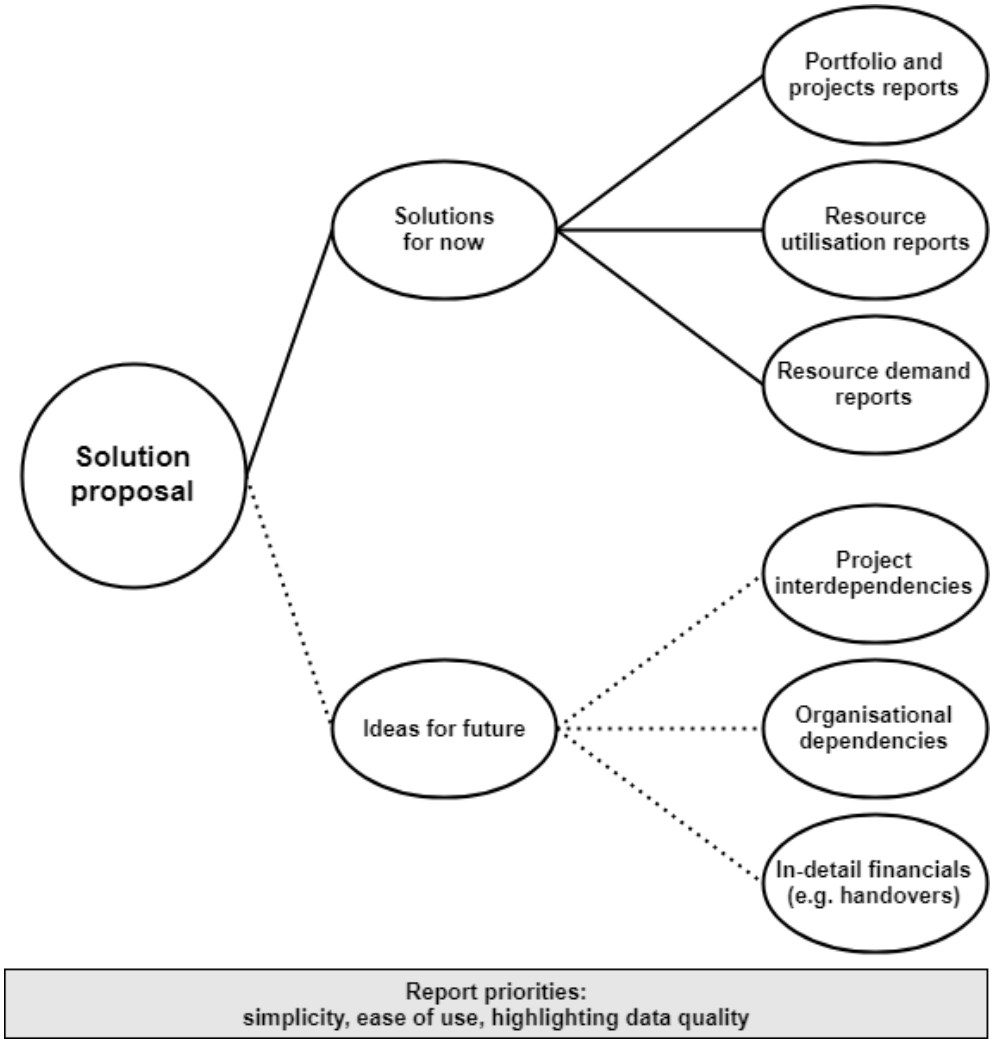

Figure 10. Overview of the solution proposal

As the figure shows, the solution proposal is divided into solution implementable right now, and ideas of what should be implemented or explored in the future. The now implementable solutions have concrete examples of the actual reports, while the ideas for the future are presented in a rougher form.

5.4.1 Portfolio and project reports

Since simplicity, and gaining understanding on a quick glance, was an important priority especially in terms of project portfolio reporting, the chosen form for the portfolio report was “traffic lights”. A crucial factor here was also the fact that traffic light indicators were already an established way of presenting project states in the case organisation, and no flaws had been found with that approach. An example of the report is presented in Figure 11.

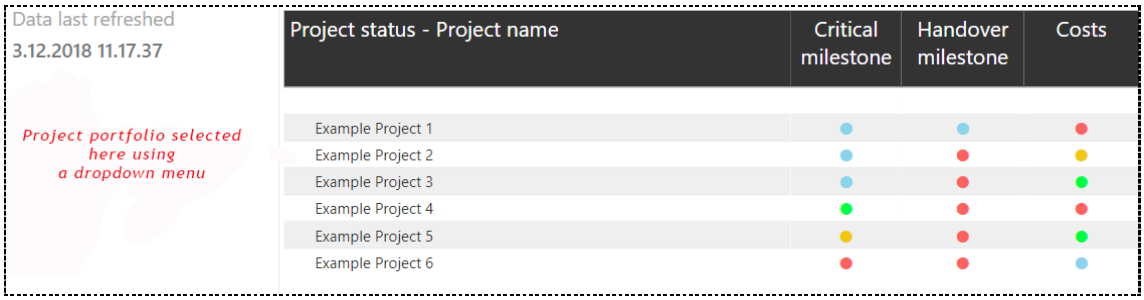

Figure 11. Portfolio traffic lights

The example presented in the figure shows how the *simplicity* is pursued by using only colours, not numbers, to convey the state of a project. In this example, something about the data quality is conveyed to the user by showing when the data was last refreshed. If a user needs more information on a project from this view, they can use the drillthrough feature by right-clicking on a project and choosing the option to move to another page, as presented in Figure 12.

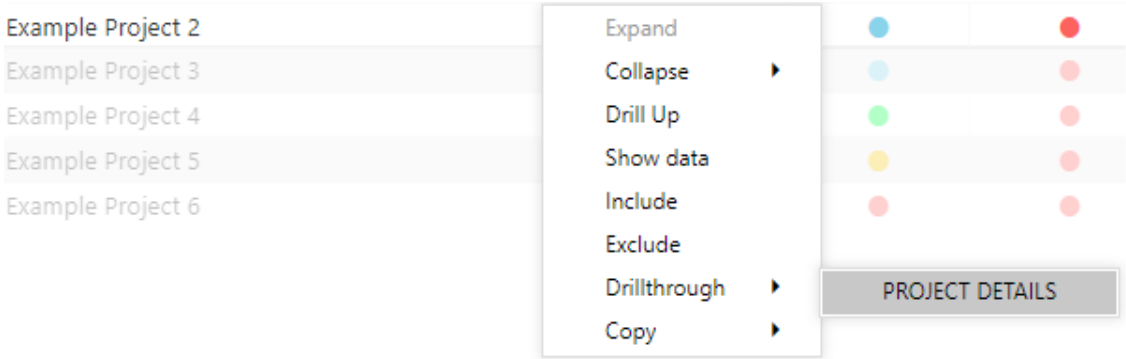

Figure 12. Drillthrough example from portfolio traffic lights view

Using the drillthrough takes the user to a page that presents a more detailed view of the project, as presented in Figure 13.

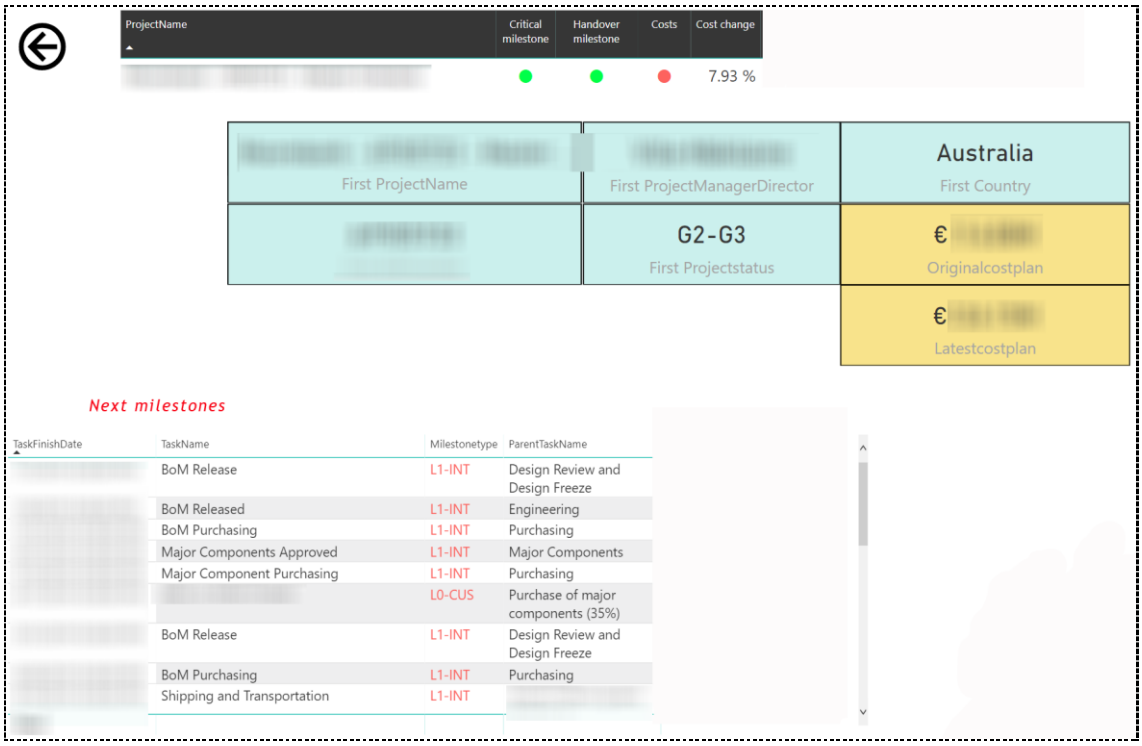

Figure 13. Project details view

The project details view presents the data on which the colours of the traffic lights are based. Also, any details not directly related to the traffic lights but the project in general, such as the target location of the project, can be presented here. Thus, while this view is introduced here as an "add-on" to the portfolio view, it could be used by employees not interested in the state of the portfolio as a whole, but only the state of an individual project. The project details shown in the figure above are only examples of what could be presented, and details could be added or different project details views could be created depending on the user needs.

If we consider the portfolio view again, the aim for *ease of use* is pursued through having minimal amount of configuration controls in the view. The most important control, choosing the desired portfolio through a dropdown menu, is also presented in Figure 11. Even though this option exists, the informational needs for each portfolio in the organisation might not be quite the same, meaning different groups of projects might need separate reports. Another control, which is rather a filter that does not necessarily need to be used, is the project status picker. As presented in Figure 14 below, the projects in this view are sorted by their gate status, and if the user does not want view all projects, but only those in implementation phase, for instance, they can choose the appropriate status from a dropdown menu.

Figure 14. Portfolio view with statuses and incomplete data

The figure above also shows how *highlighting data quality* is incorporated in the view. The black traffic lights represent situations where the needed data is missing. When the portfolio view would be adopted, the managers would immediately see if particular projects are not filling their duties in terms of data quality, and enables them to enforce control on them.

The report examples presented here are easy to modify and add data to, when the data is available. Thus, while the example portfolio view is now showing only costs and schedule metrics, the risk and customer satisfaction metrics are to be included. For now, the priority of the project details view is to present the information shown in the traffic lights in a more detailed manner, and in the example, the costs and milestones are shown with some added basic information about the project.

The key users of these reports would be upper management and those responsible of PPM at some level, for example those managing a pool of project managers. Project managers could be mentioned as secondary users, as they could have interest in the whole portfolio status, and they could also use the project details view to check, for example, the next due milestones in their project. Project managers could also use the individual project information to present data to stakeholders, such as customers and contractors, if needed.

5.4.2 Resource utilisation reports

The needs for resource utilisation reports were not as unambiguous as the ones for portfolio reporting, and there were clear differences between people and sub-organisations in this regard. For example, some managers preferred a simple view for the utilisation figure for each of their employees, while others did not have any interest in having such detailed

information, but rather wanted to how employees' time is spent in general. Thus, different types of perspectives to the matter are presented here using example reports. And while even the portfolio view had different needs for different people and sub-organisations, the unit of analysis stayed the same, as it was the project which was analysed. The changes to the presented data, at least with the tools explored here, are quite simple when the unit of analysis stays put. With the resource utilisation, the unit of analysis can be, for instance, a department, a resource pool or an individual person, which creates the need for multiple separate views, ways to modify the views. These differences between needs are specified in more detail with the following examples.

In the first explicitly expressed need, the units of analysis was an individual employee. Somewhat similar reports had already been built before, not with BI though and using different data sources, in some parts of the organisation. Thus, there was a need to build and automate the process using the data from the new PMIS.

Thus, approaching the report from this viewpoint where the ways of using the new PMIS had not yet been fully established, the report was also built to monitor those ways. The report is presented in Figure 15, where resources (employees) are represented by the rows and the percentages are weekly utilisation rates with the week starting date as the column header. The resources are grouped by pool managers, so that each pool manager can see their pool on rows next to each other.

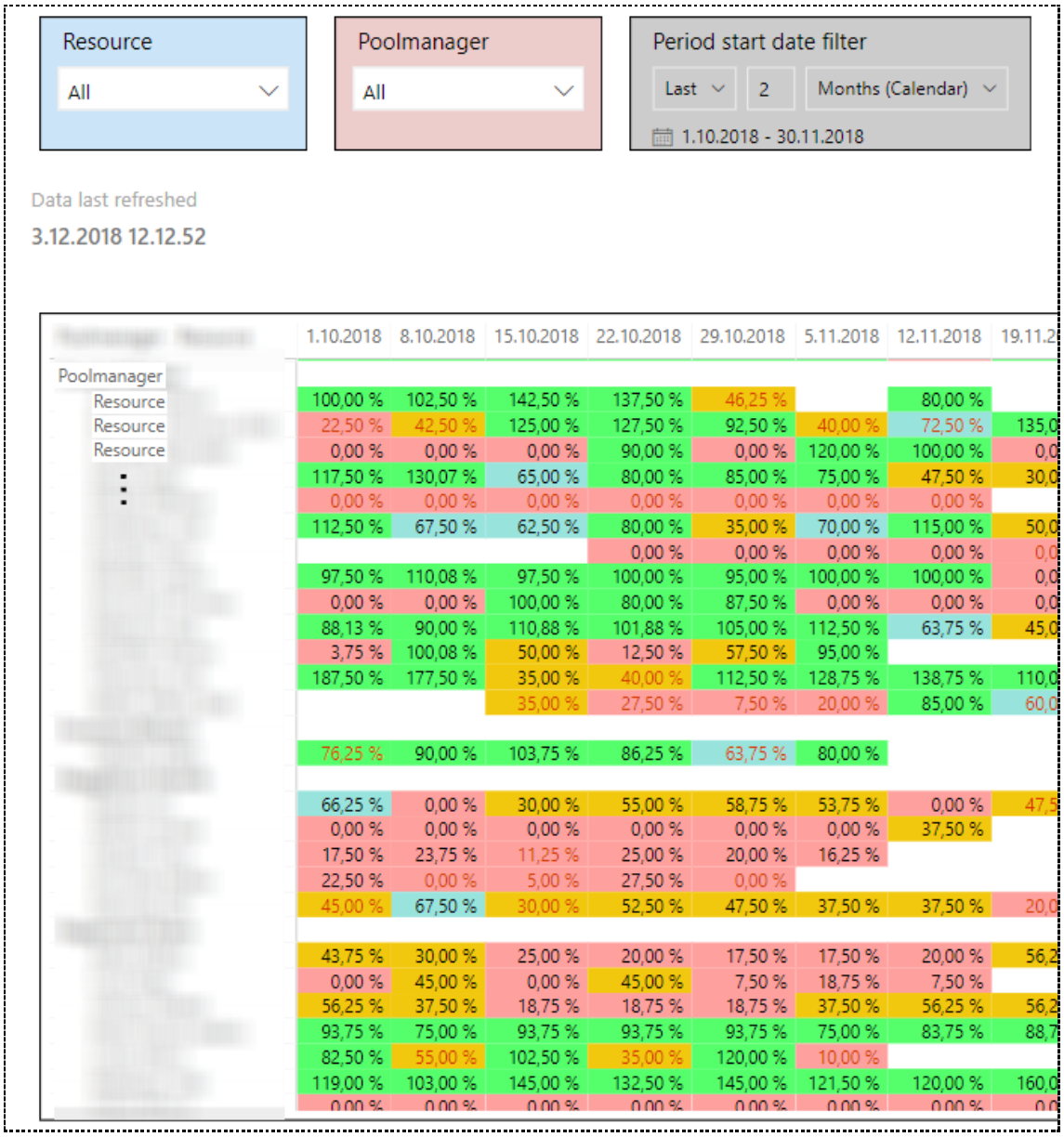

Figure 15. Weekly resource utilisation rate for employees, grouped by pool manager

The utilisation rates in the figure are calculated as *Hours spent on projects / 40 hours*. A red font in the cell indicates an employee has logged less than 32 hours (of any type of work and even vacations) for that week. As all hours should be logged there, and most people work roughly 40 hours per week, ideally, there should not be many of those cells. Also, for some cells, the data is missing completely. These observations tell that the PMIS is not yet used as it should. While this report might not follow the principle of *simplicity* presented earlier, it does let its user know where the data quality is not sufficient. However, even though the principle of simplicity is not really followed, the view does not provide that detailed information about the work hours of an individual employee either. As with the portfolio and project views, detailed views can be built here, too, using drillthroughs. Colour coding is also used based on the percentages to help users get more relevant information on a quick glance.

The working hours logged by an individual employee can be displayed through an employee drillthrough, as presented in Figure 16. This type of a view might not be useful all that often, since especially in any larger resource pools, looking at individual employees hours separated on different pages could take too much time. However, this drillthrough view was useful for building the next view, which aggregates the data of individual employees to a view of the resource pool. Pool managers had expressed the need to have a detailed view of their pools, instead of looking at individuals, and that can be displayed using a pool manager drillthrough presented in Figure 17. Both of these views also show the projects on which time has been allocated, and to help manage the data quality, the hours "missing" from 40-hour workweeks are also displayed. Per request, in the pool manager drillthrough, the hours are also highlighted if they go above 45 to notice when employees are overburdened by their tasks.

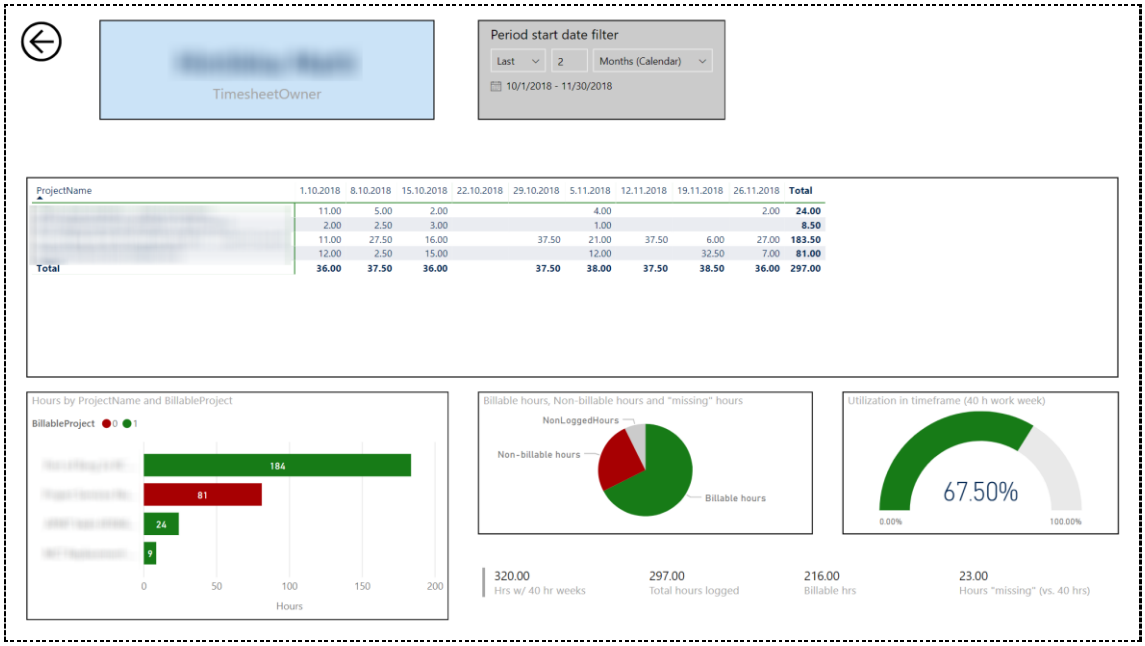

Figure 16. Employee drillthrough

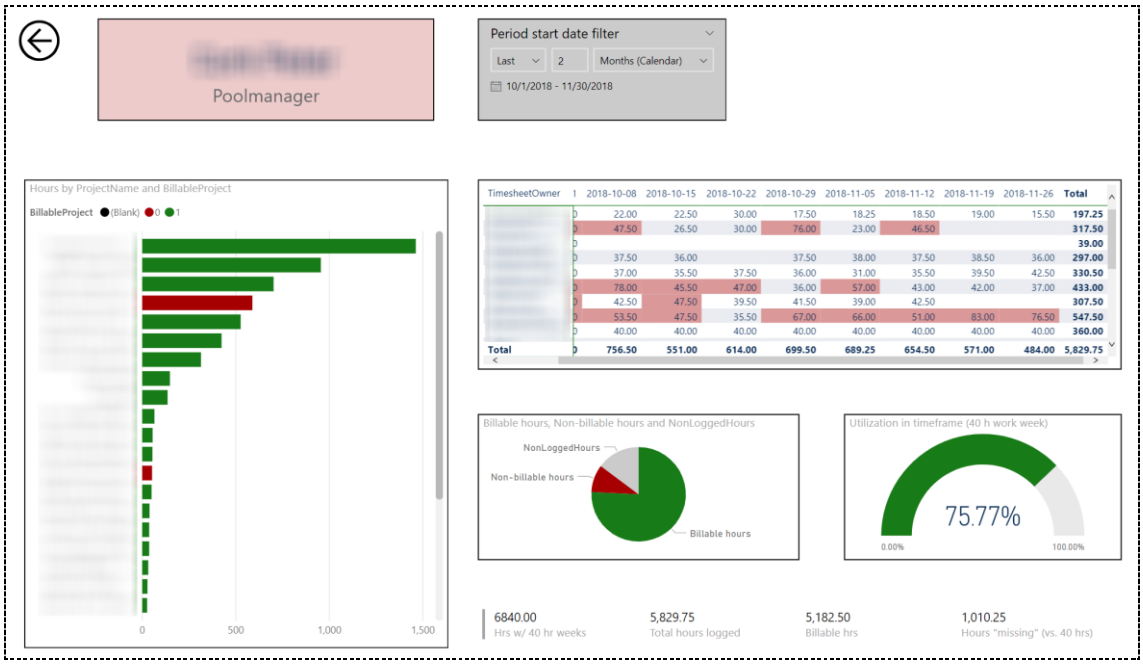

Figure 17. Pool manager drillthrough

As mentioned, some managers did not care for a view displaying the individual employees, maybe partly due to large pool sizes. Instead, the preferred unit of analysis were their teams, as displayed in Figure 18.

RBS (groups)	2018-10-15	2018-10-22	2018-10-29	2018-11-05	2018-11-12
Engineering	**51 %**	**54 %**	**60 %**	**54 %**	**45 %**
Engineering					
Engineering.ElectricalTeam	42 %	45 %	76 %	42 %	46 %
Engineering.MechanicalTeam	57 %	62 %	67 %	65 %	49 %
Engineering.SoftwareTeam	55 %	55 %	43 %	52 %	42 %
R&D	**33 %**	**42 %**	**42 %**	**34 %**	**29 %**
R&D	41 %	51 %	55 %	44 %	1 %
R&D.ElectricalTeam	43 %	44 %	43 %	42 %	25 %
R&D.MechanicalTeam	20 %	37 %	35 %	24 %	44 %
Total	**44 %**	**49 %**	**53 %**	**46 %**	**39 %**

Figure 18. Utilisation per team

For the same manager that needed the information about the teams, the utilisation rates did not seem that important after all, but he was more interested in the task types his employees spent hours on. Presenting the shares of different types of work, for teams (R&D and engineering) in the same way as in the previous figure and for the total, pie graphs are shown in Figure 19.

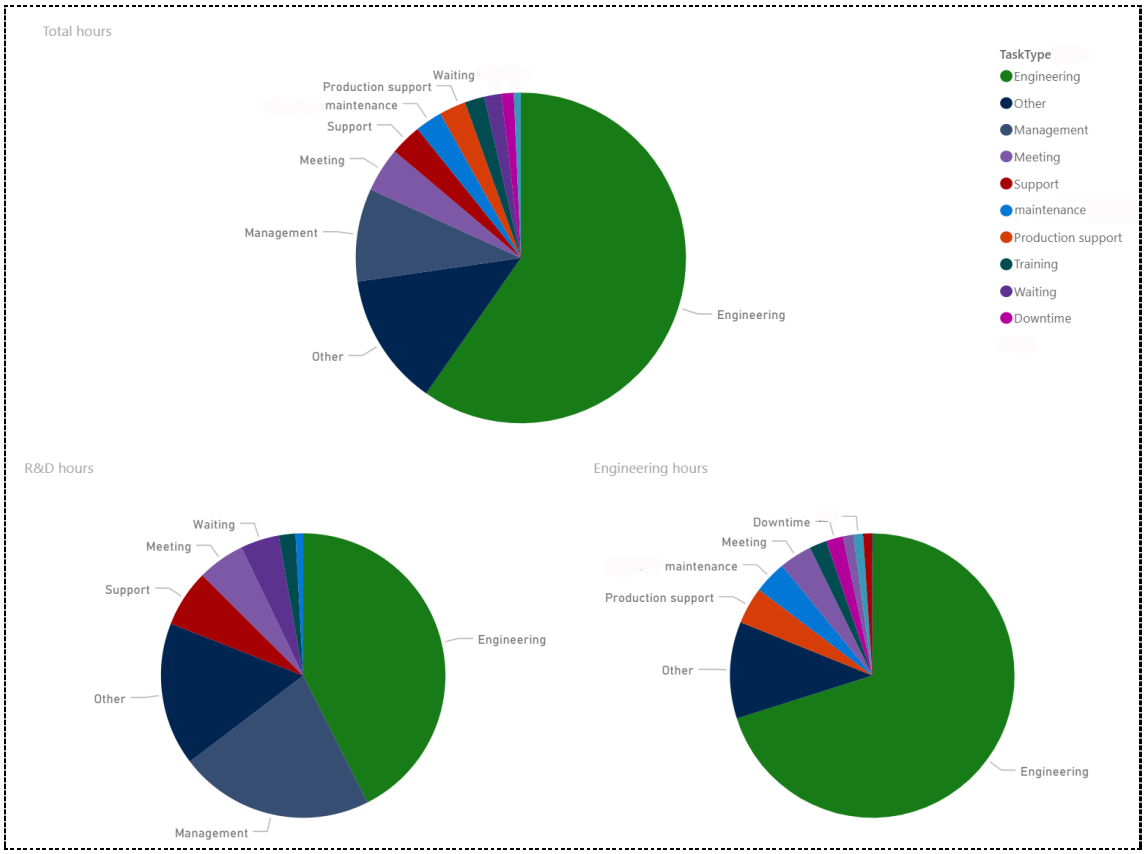

Figure 19. Resource use categorised

The categorisation of work presented in the figure was based on task naming. For example, if a task name would contain the word “management”, the task would be classified as such. Then, if a task does not fit to any predetermined category, it is classified as “other”. The report also displays the task hours and which tasks fall into which category. This is presented in Figure 20. This is seen particularly useful for the “other” category, which should help create new task categories from the uncategorised ones, if needed.

TaskType	Hours
Other	
[redacted]	81,00
[redacted]	40,00
[redacted]	37,50
[redacted]	29,00
Management	**222,50**
[redacted]	91,00
[redacted]	57,00
[redacted]	29,00
[redacted]	22,50
[redacted]	20,00
[redacted]	3,00
Meeting	**107,00**
[redacted]	57,50
[redacted]	49,50
Support	**75,50**
[redacted]	56,00
[redacted]	15,00

Figure 20. Tasks and their hours by category

The key users for the example reports presented in this subchapter would be resource pool managers. The reports are used to gain insight onto resource usage, and also to help the pool managers present their findings to upper levels of management. Thus, it would be possible for the upper management to use these reports directly, too. The employee drillthrough could also be used by an individual employee wanting to find out information about their own utilisation figures. However, this is not a prioritised use case, but rather a potential way to increase transparency and have the information available even to the individual employee.

5.4.3 Resource demand reports

Another report type related to resource management are concerned with resource demand and capacity. For the the organisation, being able to predict future resource demand better would enable better sales and recruiting decisions, among others. An example of this type of a resource demand report is presented in Figure 21.

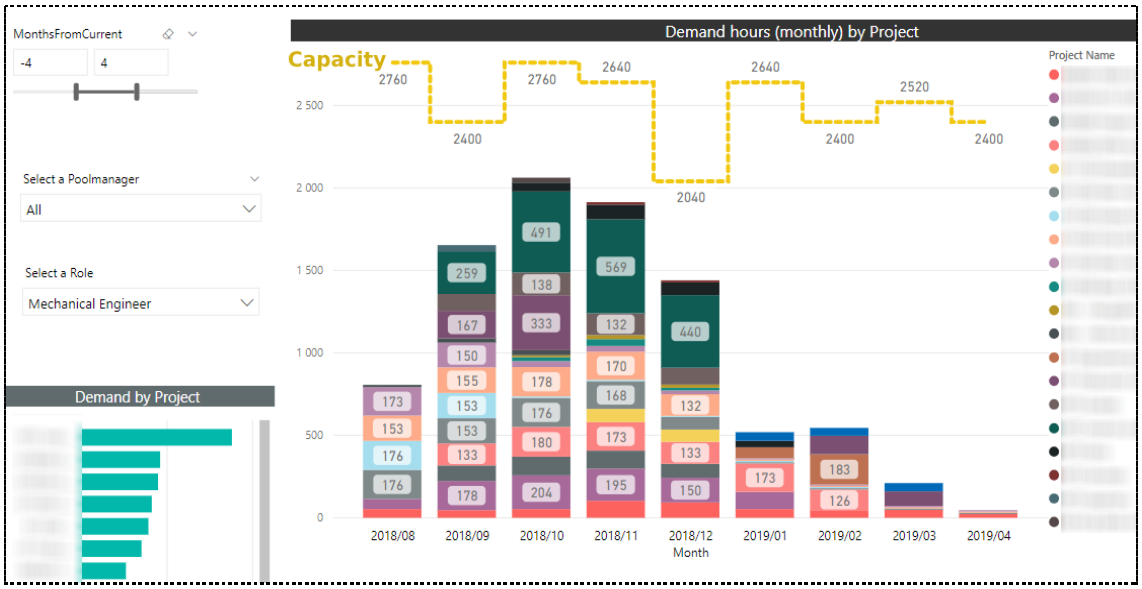

Figure 21. Monthly total capacity vs. resource demand per project

In the example, the data can be filtered with the role (as it is in the figure filtered by "Mechanical Engineer"), pool manager and time. Especially the role filtering was perceived as useful in discussions, since without limiting the representation to certain roles, it would display the total resource demand and capacity for the organisation. This information, then, might not be useful for example in terms of recruitment decisions. In addition, currently the data does not treat every role equally, since those not working mainly for projects might not be that systematic in reporting their hours. Thus, without filtering, the report might not provide much to the management of projects.

For the purposes of simplicity, such a "months from current" time selector used, as otherwise, the user would have to specify the exact dates they want to look at. Also, as we

can see from the figure, the data is lacking more the further we move on the timeline, since in reality, the resource demand (or use) should match the capacity.

The key users for the resource demand reports would be upper and senior managers, who would need to make decisions based on capacity vs. demand, e.g. for recruiting purposes. However, the use cases for this type of a report are less specifically defined than for the portfolio and resource utilisation reports. At least for now, as the data needs to be improved, the information presented in the report is more of a curiosity and a way to help improving the data quality.

5.4.4 Reporting ideas for future

Some report needs were chosen to be not described in the same detail as those reports presented in the previous subchapters. The main reason for not addressing these was the current inability to utilise the relevant data. Either the data could not be accessed due to technical or organisational limitations, or the data quality was too poor. The main types of reports (or data) are listed below:

- Project interdependencies
- Organisational dependencies
- In-detail financials (e.g. handovers)

The project interdependencies could not be implemented quickly due to data being dispersed in different systems, most importantly in the software development unit. Because the importance of software development to projects is constantly growing, this is a need that should be investigated. Some interdependencies could be modelled using only the data from the main PMIS, but it would require significant effort to change the data structures and still, the most important interdependencies would be left out. Presenting some but not all dependencies was not considered a good option, since the information could then be misleading.

The organisational dependencies have similar reasons not to be addressed in the core reports. The most important need here would be to gather data from the sales organisation, and to use it to forecast resource needs in the project operations side. Connecting this data source was not considered a priority, because it would take significant effort, and the need was not considered immediate. Luckily, these issues could also be alleviated with the reports presented previously, as now data on projects (e.g. resource demand) could be provided to the sales organisation more easily. In the future, it could be useful to combine all data into the same reports. This could, for instance, enable more advanced resource management through estimating to which extent sales projects are going to realise as delivery projects, and thus occupy resources in the future.

The in-detail financials, such current cost data, was often considered an useful part of the project reports. However, that data could not be accessed, since it is stored in the ERP system used by the organisation, which was considered difficult to connect to. Firstly, the data connectors to this data source would take significant resources to acquire and utilise, and secondly, the data source is protected by organisational policies, and not yet usable for small-scale development like this.

Additionally, an important characteristic to the case organisation was the high importance of cooperation and communication with customers. However, for now, supporting this feature of the organisation with BI is difficult. Supplying the customer with better situational information would require the organisation to have control of that information first themselves. Thus, the focus here is on internal flow of the information. Later on, BI could also be used to better communicate project information with the customers, and other stakeholders, too.

5.5 Priorities for implementation

Some priorities to assist in the implementation and development of the presented reports were found through the analysis. These are presented below.

Implementation and development priorities:

- *Development prioritisation*
    - Acknowledge all needs might not be possible to fulfil – define scope
    - What is developed, should be developed properly
- *Further development*
    - Gather feedback from users, even after reports are "complete"
    - Reserve resources and use feedback for further development
- *Know-how sharing*
    - Provide documentation for reports
    - Involve a variety of people in development

While a more detailed implementation plan could be presented here, too, it would be out of the scope of this thesis. Thus, it was this short list of implementation and development priorities, specific to the organisation, was gathered from the data analysis. Due to this, in reality, the priorities listed here are not the only ones to be addressed, but they would have to be tied to a more comprehensive framework of development. This will be done, in a more informal manner, in the next chapter, the discussion section of this thesis.

6. DISCUSSION

6.1 Characteristics and issues of multi-project environments

The first research objective of the thesis was to understand and identify current multi-project management practices and issues in the case organisation. The project management in the case organisation was characterised by solid methodologies and guidelines, while still being able to conduct various types of projects in a flexible manner. These formal processes are structured as if from a textbook, and thus they address the common project management knowledge areas outside the iron triangle, such as risks, quality and communications (e.g. Grant & Pennypacker 2006; Kwak & Ibbs 2002). For all aspects of project management, such as managing project management data and enabling fluent interaction between the processes and the data (Kwak & Ibbs 2002), there might be no textbook procedure to follow. Tools and technical prerequisites for enabling these aspects of project management were at the centre of this study, which is why organisational issues have gained significantly more attention than strengths.

In many ways, the multi-project management development areas faced in the case organisation correspond to the ones found in the literature. However, the development areas introduced in the literature review were intended as generic, and thus, finding similarities between these should be no surprise. The connections between the empirical data and literature are presented in Figure 22.

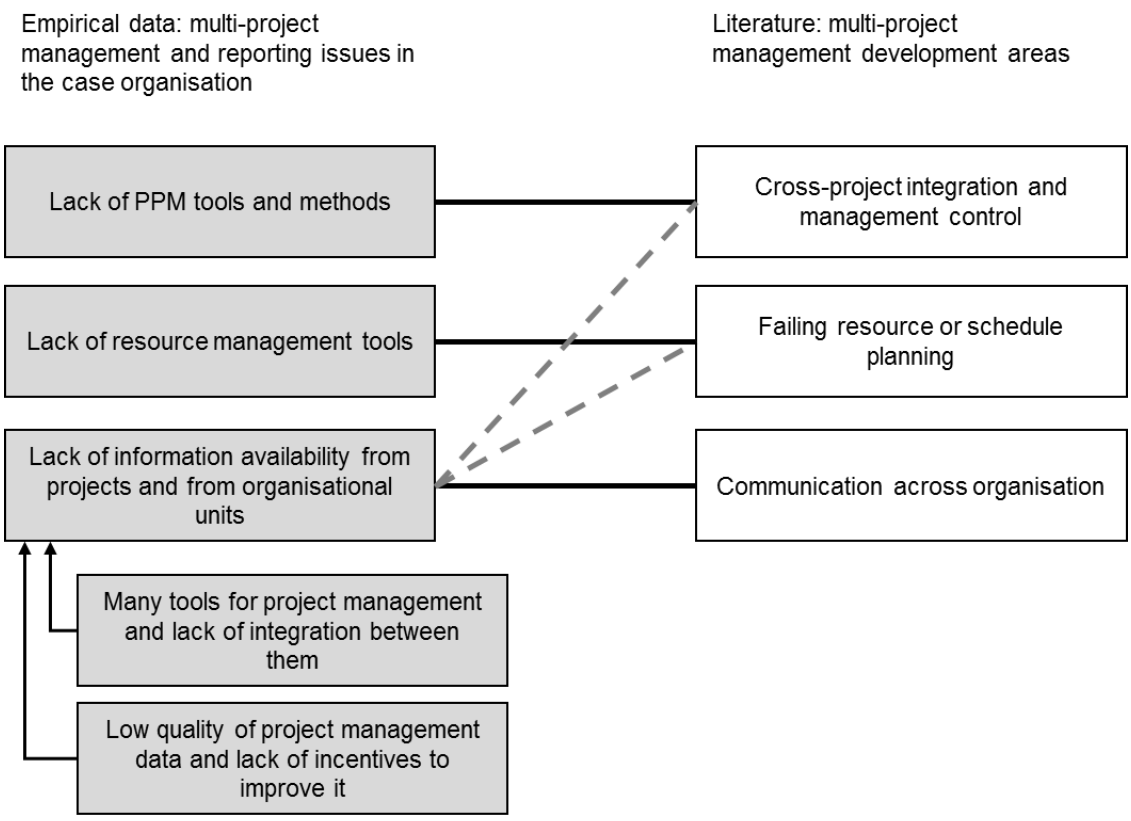

Figure 22. Multi-project management issues: empirical data and literature connections

In the figure, the issues with project management tools and low quality of project management data are considered partly at fault to the lack of information availability in the case organisation. The lack of PPM tools and methods is an issue related to cross-project integration and management control, while lack of resource management tools is considered connected to failing resource planning. However, lack of information availability in the case organisation is considered connected to all of the development areas, since this issue affects PPM, resource and schedule planning, and communication in the case organisation. Thus, improving the information availability in general could improve the organisational performance in project management in many ways. However, good intentions do not ensure good outcomes, and building additional structures on top of the old ones could even make information less available, in case the new systems confuse the users.

A notable characteristic, one not at least directly presented in the literature, was the high presence of project dependencies arising from the way development activities are arranged in the organisation. The organisation lives on delivery projects, and development activities related to the products tend to be dominated by those delivery projects, as they set the pace and requirements. These development activities are still considered R&D in the organisation, but it appears they are increasingly becoming a part of the standard delivery process for the organisation. What makes this even more complicated is the apparent separation of software development activities, which is keeps growing its portion of

the business. While the literature addresses some organisational interfaces in multi-project environments, this type seems somewhat specific, and research tends to focus on more generic interfaces, such as the sales-operations interface (e.g. Turkulainen et al. 2013). Unlike the sales-operations interface, which is in need of management in the case organisation too, the interface between projects (or operations) and software development work primarily on the same phases of the projects. Thus, more integration between the two could be beneficial, but at the same time, the work is organised differently and using separate information systems, at least in this organisation. The notion by Dougherty (1992) of departments as different "thought worlds" seems to hold here well.

6.2 Potential of business intelligence in multi-project environments

The research question posed in the study was: "How could business intelligence be used to support multi-project management in the case organisation?" Unfortunately, there is little evidence whether or not the proposed ways of using BI would efficiently support a multi-project environment, and that could not be directly explored in this study. The literature does not assess BI in project management, but it does discuss decision support systems to help with portfolio management (e.g Ghasemzadeh & Archer 2000; Killen 2013, 2017). However, the focus is on prioritisation and portfolio selection rather than the overall management of the multi-project environment, which would for instance include the management of resources. Still, based on the empirical data, it the employees felt that the types of developments pursued in this study would be useful to them, and the organisation. According to Ahlemann (2009), IT systems could be exploited significantly more in multi-project and portfolio management, and the case organisation agrees with the notion.

From a decision-making perspective, BI can be useful in automising processes related to it, and also presenting the information in a more easily digestible manner for example with the utilisation of drillthroughs and data visualisation. Assuming the data in the information system is current, users can access an up-to-date report anytime they desire, potentially making decision-making less dependent on "online" activities described by Ghasemzadeh & Archer (2000), such as meetings. For example, currently in the case organisation, project reports are produced for and introduced in meetings, essentially meaning those reports are also, at least partly, processed there, which can waste the valuable online time of employees. It was also seen that BI could help with controlling the data quality in an organisation. These abilities make BI able to impact all three limitations of bounded rationality (Killen 2017) based on Vessey's (1991) cognitive fit theory: flaws in information (monitoring data quality), human cognitive limitations (e.g. using visualisation and drillthroughs), and finite amount of time (automating decision making steps).

Centralising information, and thus being able to see a portfolio at once, and having one way to manage all projects, could make managers more aware of projects not being these isolated entities. Previous literature fails to address the concrete ways project management information could be integrated, while management of project management data is considered an important part of project management maturity (Kwak & Ibbs 2002). As Markus & Tanis (2000) describe, integrated systems for management are hopeful dreams, and that seems to hold in the case organisation. Management of the multi-project environment can be scattered across different systems, spreadsheet files and slideshow presentations. Caniëls & Bakens (2012) describe how PMISs are a way to manage complexity in a multi-project environment, and using one centralised system helps the managerial work of following up on the activities in the environment. Having multiple systems for managing project work then makes it more difficult to monitor and control the work. Thiry & Deguire (2007) conclude how organisations tend to treat projects as isolated entities. Such as a central PMIS, but more flexible, I argue that BI could act as a similar way of centralising the information for managerial use. Using BI tools could enable project managers to use the tools of their choosing, while at the same time not abandoning the idea of centralising information.

BI could be a way to unite a complex multi-project environment, where projects are heterogeneous and use different approaches to pursue their goals. In the case organisation, the environment needs to adjust to constant change, such as the growing portion of automation, and projects and departments have different needs in terms of performance metrics, project management tools and communication. In this regard, BI should fit this type of an environment well, as it can be combined with different IT systems, provides ways to continuously customise reporting and can automatise tasks that might not bring direct value to projects themselves. While BI might not restrict daily activities in the same way, as for example a new PMIS could, its potential, especially in the case organisation, is restricted by the quality of the data. It is currently difficult to see whether the solutions proposed here could work for the benefit of the multi-project environment in a larger scale, as improvements to the data quality would be needed first. However, as BI enables bringing the data available in a customisable way, it can be used as a tool to control the data quality, which can also affect the success of the PMIS itself.

In the synthesis of the literature review, potential uses of BI in a multi-project environment were introduced (Table 3). Revisiting those, the most prominent uses of BI from the viewpoint of the case organisation are related to *data integration*. BI has the potential to improve PPM through integrating data between data sources and across organisation, and thus improve information availability. In the solutions portrayed in this thesis, the resource management aspect gained a significant portion of the attention. Other potential uses of BI presented in Table 3 were categorised into *automated processing* and *data presentation and perspectives*. It was seen that other tools, such as spreadsheets and PMISs are also capable of providing these functionalities, and thus data integration was

seen as the defining characteristic of BI. However, the importance of the different functionalities seem quite case-specific, and once the organisation adopts the BI solutions, these priorities might change. For example, providing real-time data cannot be deemed crucial to the organisation in the current situation, where data quality is not at the adequate level for that.

6.3 Recommendations for the case company

6.3.1 Development in the current situation

This study has, for the purposes of starting BI development in the case organisation, analysed the initial information needs quite thoroughly. Such an extensive study might not be optimal for starting out development in terms of achieving business goals, but since the area lacks research, exploring the multi-project environment through the lens of reporting was useful from a scientific standpoint.

While these initial information needs have now been researched and analysed, the research should not stop as implementation phases begin. As Olszak & Ziemba (2007) note regarding BI development, the research of those needs should be ongoing, combined with iterative development work that involves the users in the process. As BI development could be considered essentially software development, only on a more restricted platform than in traditional software development, a simple agile model will be proposed to be used in the development work to fulfil the needs for iteration. This model, with own modifications added in the boxes, is presented in Figure 23.

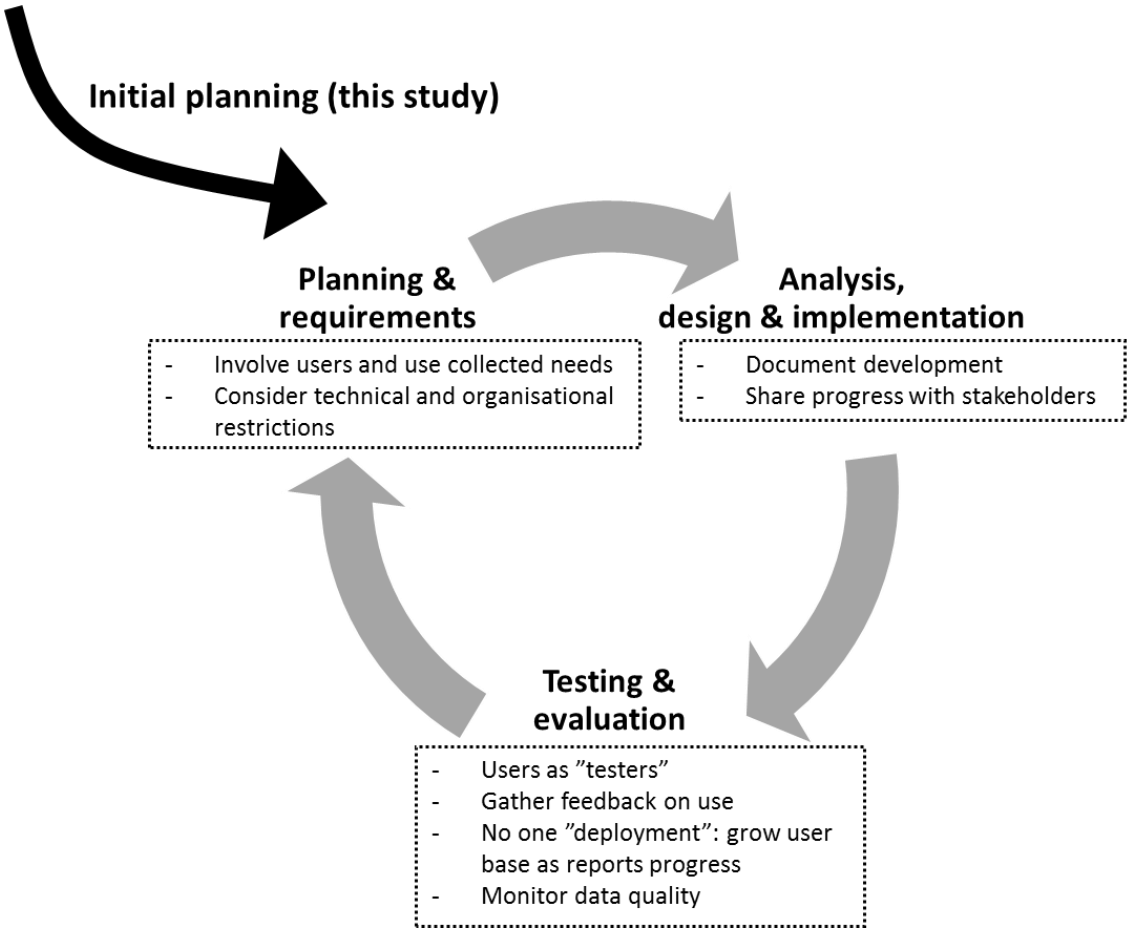

Figure 23. A generic agile development model with organisation-specific additions (modified from Moniruzzaman and Hossain 2013)

The model presented in the figure has been modified and further specified based on the limitations and other empirical data gathered from the case organisation. Regarding the limitations, it has been noted that not all of the reporting needs present in the case organisation could be fulfilled rapidly, due to scarce resources and organisational and technical issues, most importantly data quality. Gaining more managerial support is seen as a way to overcome these limitations in the long run, but for now, the feasibility in terms of these limitations is considered crucial, which also affected the choice of the initial reports presented in the results. Still, this is not only an issue specific to this organisation, but research has also shown that these types of organisational factors might be the most crucial ones in determining the success of BI (Yeoh & Popovič 2016). Thus, the development work will begin with the goal of attempting to prove the concept of BI in the multi-project environment that is the case organisation, using the report types specified previously.

Earlier, based on the empirical data, some principles were also established regarding what should be taken into consideration for these development processes in the case organisation. These principles were prioritisation of development, ensuring further development

(after “deployment”), and efficiently sharing know-how (through documentation and involving people in the process). These will be used in the actions proposed for the case organisation.

The initial planning has already been done, and this study is essentially that. In the planning and requirements phase of the iteration, it has proved as a good practice to involve users of the BI in it, as this had already been done with the interviews and many meetings related to this study. The technical and organisational limitations also need to be carefully considered within this phase, since many issues (such as connecting the solution to an organisation-wide IT system) could be seen as a waste of scarce resources at this point. For the analysis, design & implementation phase, the only added requirements would be to document the development work and share the progress of it with stakeholders to ensure adequate sharing of know-how.

The testing & evaluation phase would be affected the most by organisational factors. Firstly, with the available resources, there is little room for systematic testing. To keep key users engaged with the development process, it is seen as best practice to use a form of beta testing, meaning the users would test out the developed solutions and give their feedback. Also, since the BI solutions are built on a ready platform, no real need for systematic testing is seen as necessary. Simultaneously, the users can evaluate their experience and propose their needs and improvements for further development cycles. As the solutions are tested with users, and as the solutions get more usable, more and more users will be asked to be involved, no separate deployment phase is planned, while in the original model, it would be included. Also, data quality needs to be monitored carefully, it being a critical issue in regards to the use of BI. BI systems also often allow monitoring usage statistics, which should be used to gain objective information about the usefulness and actual users of the reports.

This type of a development cycle is currently seen as fit for the organisational context, and the goals and solutions to be developed. However, the organisation also presented other needs, fulfilling of which is not yet current, but should be discussed.

6.3.2 General considerations

Right now, the case organisation should focus on developing the three main types of reports introduced in the results of this study. However, even after them, there are vast possibilities in developing the BI solutions further. Thus, some reporting ideas for the future were also included in the results. Now, the discussion has revolved around certain types of reports, reporting ideas for the future, and priorities for development. There are still some issues to consider for the case organisation, all not necessarily important right now. These are presented below.

Raise support, drive commitment, and get feedback. The plans presented here rely on key users and them utilising the reports, giving feedback and raising awareness. To solve the technical and organisational limitations in the future, user commitment is crucial. If the solutions are useful, managerial support will follow. The goal should be to prove the usability of BI in the organisation, and the path that has been chosen is through user commitment.

Extend the scope and audience of solutions. In this study, BI solutions had been developed from a general viewpoint, from the perspective of the whole case organisation. However, different units in the organisation have different needs, and examining those units individually could provide more detailed needs for development.

Drive to integrate data. Currently, the organisation has no central system for all of project management. BI has the potential to act as a central place for any project information, without sacrificing the flexibility provided by using different systems simultaneously. This type of development will take a lot of work, but having a central system could be more than worth it.

Improve data quality. Create incentives for employees to pursue better data quality. That can happen, for example, through managerial support enforcing procedures to improve data. However, a preferred solution would be to create reports so useful that employees will find improving data quality compelling to them, without policies and rules.

Do not get hung up on plans. As the researcher has already seen in the course of this thesis, plans tend to change. For example, new technical limitations can appear, some can clear up, needs will refine, and so on. Thus, the organisation needs to be able to give up on initial plans when needed, and rather focus on achieving its goals. This thought is also at the heart of the agile methodologies, which were applied in the previous chapter.

7. CONCLUSION

7.1 Achievement of objectives

This study was done as a single-case study for a project delivery division of a large Finnish industrial machinery manufacturer. The research objectives of the study were (1) *to understand and identify current multi-project management practices and issues in the case organisation*, (2) *to identify the needs faced in terms of project reporting*, and (3) *to explore how found needs could be fulfilled with the business intelligence tools available to the organisation*.

A literature review of the relevant research areas was conducted to set a basis for the empirical part of the study. The literature review focused on multi-project management and environments, their characteristics and development areas. Three characteristics stood out from the literature: *organisational interfaces*, *interdependencies and dependencies*, and *sharing project information*. Thus, from the point of view taken in this study, the multi-project environment presents itself as a type of complex interplay between various actors. The critical development areas of multi-project environments in the literature were found to be *communication across organisation*, *cross-project integration and management*, and *resource and schedule planning*. Another distinct subject area explored in the literature review was BI and decision-making. However, the literature did not address the relationship between BI and multi-project environments, while multi-project decision-making had gained attention especially in the PPM literature. The potential of using BI to support multi-project environments was then explored in the synthesis, building on the characteristics and issues in multi-project management found earlier.

For the empirical part of the study, semi-structured interviews were used as the main data collection method. The interviews provided data on the practices of project and multi-project management in the case organisation. Formal process descriptions were also used to form an understanding of these practices, but the interviews provided a deeper and a more honest description of the needs and issues faced in these practices. The issues were noted to correspond well with the multi-project management development areas found in the literature, as both the case organisation and the literature in general presented issues in communication over organisational barriers, cross-project integration, and resource management. However, the case organisation did have nuances of its own to these issues, such as PPM and resource management lacking the needed tools, and the more traditional project organisation having communicational issues with a more modern counterpart, a software development unit. Five main multi-project management issues were found, mostly basing on the interview data:

- Lack of PPM tools and methods

- Lack of resource management tools
- Lack of information availability from projects and from organisational units
- Many tools for project management and lack of integration between them
- Low quality of project management data and lack of incentives to improve it

The importance of PPM, resource management, and information availability in the organisation emphasised the significance of dependencies in a multi-project environment, an observation also made in the literature (e.g. Caniëls & Bakens 2012; Jerbrant 2013; Killen 2013, 2017). The issues found from the case organisation, corresponded well with the multi-project environment development areas found in the literature, especially regarding information availability between actors, which was seen relevant for all three: communication, cross-project integration, and resource and schedule planning. Multi-project management has to coordinate between the actions and plans of various actors. While organisational structures create interfaces (Turkulainen et al. 2013), coordination beyond the internal stakeholders is also needed (Karlsen 2002).

This study focused mainly on the internal coordination of activities, since that was considered the natural first step, for the case organization, in starting to build on better coordination and availability of information. To answer the first research question of "How could business intelligence be used to support multi-project management in the case organisation?" the analysis based mostly on the issues the organisation was facing in its project management practices. Four main ways were found, as BI was seen as a promising way to improve PPM, resource management, information availability, and data quality. BI was seen as a promising solution, serving largely the same core function as a central PMIS would – integrating information from individual projects to allow managing a group of projects (Caniëls & Bakens 2012; Lee & Yu 2011; Thiry & Deguire 2007). However, BI could do this more flexibly, and use data outside the PMIS.

Regarding the second research question of how BI development should be prioritised in the case organisation, the answer is more nuanced, and in fact, some prioritisation had to already be done when analysing the issues of the organisation. To address the prioritisation question from the perspective of different reports, three different report types were chosen as most critical:

- Portfolio and project reports
- Resource utilisation reports
- Resource demand reports

The reports were not rigidly defined, but rather through examples and general principles to follow in the report development. Especially for the portfolio and project reports, the actual data content could be adjusted significantly along the development, while the resource reports are more constrained by what kind of information they are intended to present.

A scheduled, formal plan of the development activities was not created, since during the research it became apparent that new needs would emerge and old ones could change as employees familiarise themselves with BI in general. Also, overcoming organisational and technical issues could change direction of development. This meant that it was seen as best to modify the form and content of the reports according to the possibly changing needs, and thus, the development priorities introduced emphasised user and stakeholder involvement. Also, some possible future reporting ideas that were not seen as implementable at this time were also presented. In short, these ideas included integrating data sources between organisational units and starting to track project interdependencies better, both topics discussed in the literature (Killen 2013, 2017; Turkulainen et al. 2013), and found important in the organisation.

The research yielded satisfying answers to the research questions and the research objectives are considered accomplished. However, partly the lack of prior research into the subject area made this study also vague in terms of the objectives, and consequently results. Having previous results from a similar field of research could have given this study a more determined direction and results that could be better generalised. Still, the research done here fills an important role of exploring this quite promising combination of multi-project environments and BI.

The results of this thesis are expected to most benefit the case organisation, and hopefully have already done so at the moment this text is being written. Besides the actual intended results, the study was a deep exploration to understand the case organisation, which will hopefully result in useful insights even outside the BI context.

7.2 Contribution to existing knowledge

This thesis contributes to existing academic knowledge mainly by exploring the combination of multi-project management and BI, a union not directly explored in the previous literature. While the results of the study are difficult to generalise, the study shows that BI has significant potential to be used in complex project environments. Thus, the thesis is an important antecedent for any future research in this context. In addition, previous research focuses mainly on the technical aspects and general features of BI, while specific contexts and the potential that BI could provide in them, are overlooked. Thus, the study paves the way to better assess in which contexts BI should be used.

However, the previous research does address some similar subjects, while not specifically targeting BI. Most of this research considers types of decision-making tools, most commonly PPM through prioritisation or management of project interdependencies (e.g. da Silva et al. 2017; Ghasemzadeh & Archer 2000; Killen 2013, 2017; Killen & Kjaer 2012). Rather than exploring specific types of decisions on specialised tools, this study focused on how relevant data could be utilised through BI for the purposes of project management

in general. Replacing one-purpose tools with BI, the thesis considered multi-project management decision-making from a broader view and shed light on what kind of decisions and data are essential in a multi-project environment.

This study extends on the current views regarding PMISs, as BI can be used in similar ways. While PMISs are a somewhat popular subject of research (e.g. Caniëls & Bakens 2012; Lee & Yu 2011; Raymond & Bergeron 2008), the viewpoints would need to be extended further into multi-project management, as the systems are gaining ground on programme and portfolio management (Ahlemann 2009). The growing popularity of PMOs (e.g. Hobbs & Aubry 2007; Pemsel & Wiewiora 2013; Unger et al. 2012) seems to tell the same story – ways to manage the multi-project environment in a more comprehensive manner are needed. The research conducted here shows how PMISs and PMOs are not the only ways to achieve these goals, but BI could also serve as a solution.

The thesis provided concrete examples on possible BI reports in a multi-project environment, which can be utilised in future research. While the contribution of this thesis came from one specific industry and organisation, I believe many of the findings presented here can be easily modified into different types of multi-project environments. The study also further confirmed the problems multi-project environments are facing and showed how they could be helped with BI. Insights into the possible organisational and technical limitations of BI implementation are also presented, and they are factors to be noted when researching the implementation of BI into multi-project environments.

7.3 Managerial implications

A few direct managerial implications arose from the research, for companies wanting find better ways to integrate their project management information. Since the implications have IT, project management, and overall managerial aspects in them, they are directed mainly to IT managers, portfolio managers, PMO staff, and executives. The implications are presented below.

- **Future uses of IT system data should be considered from already in their implementation phases.** When not prepared, data quality and availability can be poor, and improving them could take significant organisational effort. For example, it can be difficult to change the routines of an organisation to start collecting new data, or connecting to organisational data sources can prove to be challenging. BI can facilitate the integration of different data sources (e.g. between ERP system and PMIS), but this should be addressed right from the start.
- **Managerial and organisational support are crucial for gathering and using data across organisation, especially in large organisations.** Support is needed to gain access to data sources, improving data quality and adopting new tools. Overcoming organisational policies, resistance to change and technical limitations, for example, can be difficult.

- **Successful implementation of BI could allow for flexibility in terms of IT tool choices.** BI has the potential replace functionalities of central systems through bringing all data to one place, and might allow teams or projects choose their tools more freely.
- **One size does not fit all, and users might not know their size.** BI solutions require iterative development and customisation between users. New types of solutions can be difficult to grasp, and finding the needs might take significant amount of time and testing. Continuous, small changes can be needed, which can make completely outsourcing the development expensive due to transaction costs. Finding the common needs between users can be used to build a "framework".
- **Using BI in a multi-project context can provide views to many levels of the business.** Features such as drillthroughs into the data can, for example, allow project portfolio level views to be clean and simple, while providing the user an effortless way to examine the details of a single project of interest.

As a common theme, managers should acknowledge that BI development can be significantly less time consuming compared to traditional software development. At the same time, BI is able to interact with large audiences, since it can combine data from almost any source. For example, all departments could use the same BI solutions, while developing or implementing using other type of a solution could take significantly more effort. And as it was noted in this research, individual systems tend to not serve all users equally. BI can be the solution that enables both the use of different systems for different purposes, while also integrating the data between these systems, giving managers a chance to get the big picture.

7.4 Research limitations

There are some limitations to the applicability of the results of this thesis. Due to the nature of the single-case study, the results are difficult to generalise. This limitation was compensated through describing and attempting to understand the case organisation thoroughly, and thus allowing to disseminate the characteristics specific to the organisation from those seen as more general. For example, the pursuit for better forecasting of resource demand could be considered a general issue, while the dynamics of organisational interfaces may highly vary between organisations and industries.

Semi-structured interviews were used as a primary method of data collection in the study. The interviewees were chosen using a suggestion from the case organisation and attempting to involve employees from different relevant roles. Thus, the interview data gave a broad view to the organisation, but the sample was somewhat small, making the data not representative of the organisation as a whole. With this in mind, the exact significance of different issues and characteristics in the organisation could not be determined, which would have been difficult anyway, due to the qualitative nature of the research. However,

the most significant issues presented themselves in multiple interviews and in the research diary data. Still, the research diary as a data source had its own flaws, mainly due to its subjectivity: the data collection was prone to biases on the behalf of the researcher, and also people involved in this data was a highly specific subset of employees in the organisation.

As a general issue reducing the reliability of the study, it should be acknowledged that the researcher was closely involved with the case organisation, and also prior to the study. Thus, biases are likely, as any preconceived notions about the organisation can disrupt one from seeing and dealing with issues objectively. These biases may have affected the data collection both regarding the interview and research diary data.

To minimise the impact of these potential biases on reliability, the triangulation of interview and research diary data was used. In addition, other secondary data sources, such as the organisational documentation, were used to further confirm the findings present in the data. The research diary data was also formed through a long, six-month period, consisting of constant collaboration with the employees of the organisation. Thus, the decisions and findings in that data were subject to continuous feedback, discussion and examination. This close involvement and prior understanding of the organisation might have also helped the researcher focus on the less apparent, deeper details regarding the organisation.

The lack of directly relevant literature in the subject area of this research also limits validity of this research. Due to this, the potential benefits of BI in a multi-project environment had to be combined from different streams of literature, subjects including multi-project management, BI and decision making in general. Thus, some conclusions made in the literature review might suffer from lack, or poor quality, of evidence.

7.5 Recommendations for future research

As the literature for BI from the organisational viewpoint, and especially regarding multi-project management, is quite scarce, the work on this thesis has brought up many potential subjects for future research. Overall, the literature does not seem to address BI and its relationship to its contexts, the organisations.

One rather implicit reason for conducting this thesis was, for the case organisation, reducing the amount of time spent on reporting and related activities. It is clear that BI can enable the automatisation of some of these processes. However, it should be explored, to which extent could BI replace traditional forms of reporting, such as periodic or situational reports from production or projects. If traditional handcrafted reports could not be fully replaced with BI solutions, one has to figure out the division of labour between these two. Also, in general, an interesting research topic would be the suitability of BI in different organisations. This thesis contributed to that topic from the viewpoint of a multi-project environment, but due to the lack of prior research, this study had to take a rather

explorative perspective into the subject, instead of being able to confirm the usefulness of BI in the context. Another avenue of research could be to explore if, and to which extent, can BI affect the information transparency and availability in organisations, and what are the roles of different mechanisms of BI, such as automatisation, visualisation, and data integration. As BI is a solution that often builds on top of other systems and organisational structures, researching the implementation process of BI in different contexts could prove useful for organisations.

In the more specific context of this thesis, the multi-project environment, literature addressing BI is practically non-existent. Surely, however, project organisations use BI solutions already, so research into the use would be useful. Exploring how BI is used to support project management could help organisations create new ways to utilise it and assist academics in better understanding the potential in this context.

In general, the topics discussed in this thesis would require both further exploration and describing the use of BI, especially in different contexts, but also quantitative measurements to prove the benefits of BI. Currently, BI seems to be used for better, and more efficient ways of managing business, but there is little scientific basis for the perceived benefits.

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APPENDIX A: INTERVIEW STRUCTURE

Before the interview, ask permission to record and tell that the recordings will only be used by the interviewer. Permission for any other use will be asked separately.

Background

- Name
- Team (or other organisational entity)
- Current position, responsibilities
- Briefly describe your history in the case company (time, roles, road to current role)
- Role in project business
    - What kind of work do you do for projects?
    - Do you tend to allocate your time directly to projects or do you work in "supporting" tasks?
        - If directly to projects, how many projects are you generally occupied by at a time?
        - Does the amount of projects cause any problems, for example in terms of knowledge management?
    - Are there any particular types of projects you tend to be involved with? (E.g. delivery vs. development, mega projects vs. smaller ones)

Project success criteria

How do *you* determine if a project is a success? Subjective opinion.

- (examples: schedule, scope, budget, end value, quality, reputation, project management success, communication, customer satisfaction, employee satisfaction)

Which factors do you see as leading to project success?

- (examples: satisfied workers, right amount of concurrent projects, right resources)

Metrics & information needs

What project or business question do you need answers to? (e.g. budget, schedule, employee/subordinate utilisation)

- Questions that would follow?
- Actions that would follow? What do you do with the information?
- Who needs the answer? Who is taking the real action?
- Why is it an important question/answer?

How is the question answered, i.e. measured? (How could the question be answered?)

- Is there a risk this measurement would result in unwanted behaviour? (I.e. optimizing work strictly for the measurement)

- What other measurements are related to this measurement? (I.e. what other measurements e.g. correlate with this one)

Data & information systems

(If a suitable metric comes from previous theme) → Does needed the data exist?

- If not, could it be collected?
- If yes, where?

What systems/software do you use? (for data collection, project management)

- Questions about the systems:
    - Users?
    - For what is the system/software used?
    - Is the system suitable for your purposes? Why is it used?

Project management & decision-making

- Describe the decision-making situations you're involved in
- [Going through the situations one by one]
    - Who are the decision-makers? (roles, dominance between people)
    - What is the situation? (meeting, one-to-one meeting, individual work, etc.)
    - Do someone produce reports for that situation? What kind?
    - If meeting, do you feel everyone has the same information? Are there recurring issues of people not having the same information?

Dashboards & reports

- Overall, what kind of reports are you using now
    - Example inquiries:
        - Are they periodical, for demand, or automatic?
        - Are they dynamic or static? (I.e. can you for example filter them)
        - Do you feel the reports are useful or are they done just for the sake of reporting?
        - Could they be automatized?
        - In them, what is the data that actually needs attention?
        - How is the information visualized?
            - Why this way? Is it optimal?
        - Do you consider the information reliable? Why, why not?
- Have you created any project reports or views yourself?
    - If so, describe them briefly (purpose, users)

Example project(s)

Give an example of especially successful, especially unsuccessful, typical project (or group of projects) or memorable project (or group of projects) that comes to mind

Example inquiries:

- What made the project(s) stand out?

- Which project(s)? What type?
- How was the reporting performed?
    - Was the reporting/communication a success?
- Were there other ways the project progress monitored and communicated?
- What were the performance indicators used?
- Are there any indicators that could have been useful, in retrospect?
- Were there distracting, non-relevant indicators present?
- What kind of decisions were there involved, and how were they made?
- What parts of the project were successful?
- What parts of the project were unsuccessful?
    - Could they have been corrected, if recognized early?
        - If so, how?

Ending the interview

- Is there anything else you would like to comment regarding the subject of this interview?
- Encourage the interviewee to contact you if the subject inspires new thoughts later on.

APPENDIX B: INTERNAL STEERING GROUP MEETING PRESENTATION CONTENT